M. Abbott

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THE PRINCESSES.—BY GOTTFRIED SCHADOW.

SCHADOW'S GROUP OF THE PRINCESSES.

THE youthful princesses Louisa and Fredericka von Mecklenburg, who married the Crown Prince, afterward King Frederick William III., and Prince Ludwig of Prussia, charmed all classes of society in Berlin, and the great aim of artists of the day was to portray their beauty and loveliness worthily. Gottfried Schadow, who was then a young artist, modeled two busts, and afterward received an order for a life size group of the princesses. When this work appeared in 1795 at the Art Exhibition in Berlin, it met with such universal approbation that its execution in marble was determined on, and thus one of Schadow's best works was preserved to us.

We have the artist's own account of the conception and later fate of the group. He tells us with what enthusiasm he worked on the model, how he took the measurements from nature, how high ladies loaned him whatever he desired from their wardrobes, and how the headdress of Princess Louise, with the band which she wore under her chin to hide the swelling in her throat, was adopted by fashion. He also tells us how he substituted light drapery for the flower basket which the elder sister originally carried in her right hand, without changing the position of the arm, and how the altered model was executed in marble with greater care than any of his other works. We regret, with the artist, that this masterpiece was doomed to oblivion so soon after completion. When the Princess Fredericka, who early became a widow, gave her hand to the Prince of Solms against the wishes of the court, this group became obnoxious to Frederick William III., and was consigned to a chest, where it lay for years. Finally it was placed in an out of the way hall in the Berlin Palace, but there it was in such a dark corner that it could scarcely be seen, and remained almost unknown until the jubilee exhibition in Berlin last year.

We sometimes find a certain hardness in Schadow's creations, but he treated this group of the princesses in his most attractive manner. He was very successful with the expressions of the faces, and in pose and drapery he followed the ideal beauty of the antique. This beautiful group is one of the most interesting works of modern art.—*Illustrirte Zeitung.*

THE PANAMA CANAL.

THE following is the paper on "Some Difficulties to be overcome in making the Panama Canal" read by Dr. Wolfred Nelson before the American Association for the Advancement of Science at the Buffalo meeting.

The Panama canal, as explained by M. De Lesseps, is intended to connect the Atlantic and Pacific oceans. Its length will be forty-seven miles. The canal after leaving Colon on the Atlantic closely follows the line of the Panama railroad, both crossing the swamps and quicksand in the Mindi section, thence on to the Indian village of Gatun, some eight miles from Colon beyond, the railway also and the canal will cross the Chagres river. Ere reaching Emperador, the canal will cross the railroad several times. Two miles beyond Emperador is Culebra, or the "Summit" section. The railroad at Culebra is 239 feet 6 inches above the level of the Pacific ocean. From Culebra by a series of windings it will reach the valley of the Rio Grande, thence to the Pacific, terminating at Rio Grande, a small Indian hamlet at the mouth of the river of that name, in the bay of Panama, about one and a half miles from the city of Panama, or modern Panama, built in 1688.

In the valley of the Rio Grande the canal will have to cut through swamps and small streams, and have for its immediate neighbor the Rio Grande or Grand river. For several miles inland there are numerous small arms of the sea, connecting with the river. At low water they are almost empty, at high water they have ten and twelve feet of water in them. At Pedro Miguel, six miles from Panama, on the line of the railroad, one of the arms, or "sloos" as they are called in California, reaches the railway embankment, the latter being but a few feet above the level of the swampy soil.

On both sides of the Isthmus, the canal will pass through several miles of swamps, on the Colon side through swamps and quicksand and hard coralline formation, on the Panama side through swamps and an extensive ledge of volcanic rock.

Having briefly referred to a number of localities on the Isthmus of Panama, let us consider a few of the prominent and best known difficulties to be overcome by M. De Lesseps, if the Panama canal ever becomes a fact.

Let us start at Colon. The island of that name is 1,980 miles from New York City, on the bay of Limon. The island is about a mile long, by an average breadth of say one third of a mile. It is of a coralline formation, and abounds in lagoons and mangrove swamps. The city of Colon, formerly known as Aspinwall, is the Atlantic terminus of the Panama railroad. The island and mainland are connected by the railway embankment.

The Atlantic entrance to the canal is just beyond the embankment. Through the swamps in that vicinity, a cut, perhaps of two miles, has been made. It was cut down to a depth of thirteen feet, but repeatedly the material thrown out has fallen back into the canal to be dredged out anew. The swamps and pockets of quicksand extend inland for several miles.

In building the Panama railroad, the chief engineer, the late Col. Geo. M. Totten, met with serious difficulties in theses swamps and quicksands. It is stated that his staff in surveying there failed to get bottom in 180 feet, but as he was building a railroad the difficulty was overcome, as at Chat Moss, by throwing in immense quantities of wood and earth, then making the roadbed over the sunken material. The swamps and quicksands are said to be quite an undertaking. Some canal engineers have stated that the waters of the Chagres can be utilized to flush the immense pockets of quicksand out to sea. Excellent, if possible, but, if possible, what becomes of the deep water harbor at Colon, at the head of the bay of Limon? Next in order, let us consider the huge problem of

DAMMING THE CHAGRES RIVER,

near Gamboa, well and happily named by M. Levelley, a celebrated French engineer, now living, *la grand inconnu* or "the great unknown" problem of the Chagres. This truly will be a gigantic undertaking. The Chagres river drains an immense area of country between ranges on the Isthmus, and extending far inland to the south. The penning up of its waters will be no mean task. The almost periodic misdoings of this large tropical river will receive due attention anon. When I left Panama in April of this year (1886), the problem had not been solved, or, if solved, the solution had not been made public. Between February 28, 1881, and April 12, 1886, innumerable surveys had been made by their best men. Survey after survey has afforded no consolation to the company, and the controlling of that tropic torrent seems almost impossible. A canal engineer who had spent several months on that survey said to me: "The damming of the Chagres seems a hopeless task. I, as a Frenchman, should not say so, but it is true nevertheless."

If completed, the presence of an immense body of water in the immediate vicinity of a tide level canal will be a constant source of danger. M. De Lesseps, in his estimates, named 100,000,000 francs or $20,000,000 as the probable cost of the *barrage* or dam at Gamboa. The dam will be 47 feet high, 330 feet in thickness, and over half a mile long. No one but an actual resident in the tropics can form an accurate idea of what a tropic downpour means. The late Capt. Dean, who had lived on the upper Chagres, told me that he had seen it rise sixty feet as a result of only twenty-four hours' rain. Rains there often fall for days together. As already stated, the sole outlet for the waters is by the Chagres. Further, when we know and attempt to realize that the valley of the Chagres, near Gamboa, has no rocky bottom on which to build the colossal dam, we are dazed at the daring of the whole scheme. American and English engineers pronounce it impossible, and in spite of the French surveys it remains "the great unknown of the Chagres." The damming of the Chagres of necessity means a new bed for it. Such is intended, a new outlet near the island of Colon. Passing from this truly well watered scheme, let us continue on to Emperador and the Culebra section. The huge slice to be cut out of the Emperador-Culebra hills probably is the

GREATEST PIECE OF EARTH CUTTING KNOWN.

Those who have watched the Panama canal scheme from its very inception, and the visit of De Lesseps' now famous engineering commission to the Isthmus in 1880, will remember that the level of the railroad at Culebra—239 feet 6 inches—was used as a basis for calculating the cube of earth and rock to be removed, Culebra being the lowest pass found in the hills during the careful surveys for the Panama railroad. Fully two years after the landing of De Lesseps' engineers the Culebra pass was not found suitable. To use it would make the bend or curve in the canal too sharp. The next best was found in that vicinity, but one hundred feet higher up, or 339 feet 6 inches above sea level, thus adding enormously to the cube to be removed as well as the cost. The first had been roughly estimated at 20,000,000 cubic meters, and the latter 40,000,000 to 50,000,000. In 1883 a commission of

U. S. NAVAL OFFICERS MADE A REPORT

on the canal. It was estimated by them that the Culebra cut alone would take fifteen years' work. Captain, now Admiral, Bedford Pim, R. N., who knows the whole Isthmus thoroughly from surveys conducted by him for the English government, visited the Isthmus in the fall of 1884, and had unusual facilities given him for seeing everything on the axis of the canal. He estimated that fully ten years would be necessary to complete the Culebra section. His report to the late Secretary of State Frelinghuysen, later, was published. A series of drillings by an American contractor for the canal company very materially added to the knowledge of the Culebra. At a depth of 75 to 100 feet below its surface, a bed of intensely hard rock was found, so hard that the diamonds were torn out of the drills. In the original estimates the sides or banks of the Culebra cut were calculated, it is said, at one in one. Men of experience, now on the Isthmus, state that such an angle is impossible in a country when the rain falls in torrents. A gentleman now there, who can speak from an actual residence of twenty years in the Isthmus and west coast of Central and South America, and formerly in the employ of the Panama railroad, stated that banks on the Isthmus to have any stability must be one in four, and *apropos* of sharp angular banks, he cited some of the Panama railroad company's experience. A forty foot cut was made at Paraiso, with banks of the one in one type. Following rain, down they came, burying the railroad to a depth of twenty feet. A single experience was sufficiently instructive. A new track was laid on top of the old one. Such was the railroad's experience with banks simply forty feet high. Now, then, let us consider the banks of the canal cut at Culebra.

Place before your mental vision hills 339 feet 6 inches above the sea level, carry a perpendicular line to sea level, then add 27 feet 6 inches to reach the floor of the canal. The latter will be 72 feet wide at the bottom. The perpendicular line from the surface to its meeting the line on the floor of the canal will measure 367 feet. The canal, at water line, will be 92 feet wide. Calculate its banks at one in four to the surface. The surface cut will be nearly three quarters of a mile. Such were the figures given by an experienced engineer who made the calculation. Where the millions of cubic meters of rock and earth are to be placed, when loose, has not been determined. Certainly there are no dumping grounds in the Culebra district. Next in order we shall consider

THE RIO GRANDE RIVER,

its valley and surroundings. Standing on the highest part of Mount Ancon, just back of the city of Panama, at an elevation of 504 feet, one looked down on the small hamlet of the river of that name, minor streams and miles of swampy country. The condition of the river and swamps of course depends upon the tides of the bay of Panama, the latter varying from sixteen to twenty-two feet. The Rio Grande district offers difficulties that were unknown to M. De Lesseps and his engineering commission of 1880. Three years after the landing of the first canal expedition of engineers, a party of American engineers in the employ of a canal contractor made known the exact nature of the swamps of Rio Grande and the underlying formation. M. De Lesseps and his commission simply glanced at it, looking upon it as a peaceful, malaria-producing swamp. As the result of the surveys by the American engineers, instead of a swamp only, a huge ledge was found at a varying depth of from twelve to sixteen feet below the surface. The canal, if ever pushed to completion, must cross it, and there Mr. Dingler's immense tidal basin must be built. This was rather an unpleasant surprise, particularly as it came upon the company after three years' residence of their own engineers there. It is simply another illustration that the canal scheme was entered upon hastily and almost without any accurate knowledge of the nearly insurmountable difficulties that surround M. De Lesseps' scheme.

APROPOS OF TIDES,

the tides of the Atlantic at Colon rise only some sixteen inches, while those at Panama vary from sixteen to twenty-two feet. Hence the necessity for a tidal basin in what M. De Lesseps calls a sea level canal. The plans for this tidal basin, those designed by M. Jules Dingler, late director-general of works at Panama, are said to be very fine. They were exhibited by him to a commission of naval officers of the U. S., in 1883. The basin will contain a series of magnificent docks, built in stone, the basin to cover three quarters of a square mile. An engineer on that survey said that the basin as planned would cost fully $30,000,000. Let us leave its difficulties, but too briefly referred to, and consider elements that at all times threaten an Isthmus canal, the vast inundations that fill the valley of the Chagres, and flood the country for many miles. Reference has already been made to Emperador and Culebra—or the "summit."

Emperador is about twelve miles from Panama over the "divide" on the Atlantic side. Between Emperador and Gatun, the railway runs along several valleys, following streams, etc. As stated, the canal closely follows it. Some nine miles from Colon, hills of considerable size are met. The flood in the fall of 1879 may be taken as a fair sample of Isthmian floods. It was the result of the usual weather at that season of the year when the wet season is closing. After days of wind and rain, the river Chagres overflowed its banks, and a flood filled the valley. The Panama railroad was covered in places by

TWELVE AND SIXTEEN FEET OF WATER.

Mr. Pedro Sosa, a Colombian engineer, took a bungo or native canoe at Tiger hill, about nine miles from Colon, and proceeded direct to Emperador, or over twenty-six miles of the projected canal. That flood lasted four days. Houses were washed away. In places the railroad disappeared, the rails and ties were bodily removed to new resting places. Several miles of the railroad were found covered by earth washed in by the tropic torrent. The deposit of earth varied in depth from a few inches to several feet. In December last (1885) and January of this year, severe "northers" blew at Colon, rains fell. Some twenty vessels in the harbor of Colon were wrecked and forty lives were lost. Again a part of the Panama railway was under water, and traffic was suspended for two or three days. These floods have occurred about every six years. The treacherous "northers" that have wrecked so many vessels at Colon are historic. What would become of a canal, particularly a sea level canal, under such treatment can be imagined. Description is unnecessary. Strange to say, the knowledge of these floods only came to the company after three years' work on the Isthmus. Mr. Robert K. Wright, Jr., formerly of the United States navy, at that time an engineer in the employ of the canal company, made the studies, got the exact information, and laid it before the company. This was a new and truly "great unknown" to the company. Next in order, let us say something

ABOUT THE CLIMATE.

It is and always will be pestilential and death dealing. Those familiar with the history of the Panama railroad know all about it. Those who do not can obtain valuable information by reading "Panama in 1885," by R. Tomes, Harper Brothers, New York. Yellow fever has been endemic for many years. It was epidemic in 1854, 1868, 1880, 1884, and again in May and June of this year. When I left Panama in April of this year, there were many cases in Panama and Colon. During March there were forty-three deaths from it in Panama and fifteen in Colon. The *Star and Herald* of Panama, on its Spanish side, published the heavy death rate among the Colombian troops in the Panama garrison. In the first quarter of 1885 yellow fever, dysentery, and tropical diseases killed fully one fourth of the admissions to the hospital. In May and June, during the height of the epidemic of yellow fever on the Isthmus, the death roll was given by the *New York Herald* as forty per day; later the same paper said forty a day was within the truth. During the month of August, a vessel, the Agnes Campbell, arrived at Biloxi, Miss., direct from Colon, with yellow fever on board. Between September 15, 1884, and January 30, 1885, an epidemic of yellow fever developed in the shipping at Colon. There were fully one hundred and fifty cases, with a mortality of two-thirds. In July, 1884, the *Star and Herald* published the death rate among the canal men of all ranks as being 109 per 1,000.

The heaviest death rate stated unofficially in canal ranks was in November, 1884, when 653 officers and men were buried. The magnificent system of hospitals at Panama and Colon amply attest M. De Lesseps' knowledge of the climate, well known in the old country as the "grave of the European." The system of hospitals, some sixty-five buildings at Huerta Galla, Panama, have cost over $2,000,000.

YELLOW FEVER

sweeps away the whites, while pernicious fever kills both blacks and whites, the latter due to intense malarial poisoning. As to how yellow fever kills, I will cite the experience of the ill-starred Dingler expedition. It consisted of a party of thirty-three, and reached Colon October 29, 1883. Within three weeks Count de Cuerno and Mr. Zimmerman had fallen victims to "Yellow Jack." Later Miss Dingler died, then Mr. Dingler, Jr., and finally Mrs. Dingler. Between the date of their landing, October 29, and January 22, 1885, or within fifteen months, fourteen of that party of thirty-three had had yellow fever; but one recovered. Pernicious fever attacks all, from infants in arms to able-bodied men in the works. Its invasion is so sud-

den, that many are stricken down while at work, the disease as a rule terminating fatally within thirty-six hours. In July, 1884, a new cemetery was opened in Panama. Its opening was the occasion for a holiday, a parade of troops, and the presence of a band of music, leading government officials made speeches, and the place took on a holiday air.

Between the day of the joyous opening and the 12th day of April, 1886, when I left the Isthmus, it had been filled, and a new cemetery opened without any music was partially filled. The last grave bore the number 3880, plain black crosses with the year and number marking the last resting places of 3880 individuals. This cemetery receives all the canal dead on the Panama side; apart from those buried in the earth in this cemetery, several hundreds of the middle and upper classes were buried in the *booredas* or stone vaults. During the same interval, the foreign and Chinese cemeteries received their hundreds, and there were a few interments in the Jewish cemetery. The

COST OF THE CANAL IN LIVES

up to April last has been fearful. To send unacclimated people to the Isthmus is almost certain consignment to death. Finally, let us refer to the Isthmus, and seismic troubles. There is a history of earthquakes extending back for several centuries. In 1858 a severe earthquake visited the Isthmus, and many of the strongest walls in the city of Panama were damaged. The great earthquake of September, 1882, deserves special mention. At 3:30 a. m. on September 7, 1882, the whole Isthmus was violently shaken. In the city of Panama the cathedral was seriously damaged, a part of its *facade* was thrown into the Plaza square. A part of the *cabildo*, or town hall, was likewise thrown into the Plaza, its stone columns and a part of the roof were in ruins. Ruins were shaken down. All the buildings in the city were damaged. At Toboga, an island in the gulf of Panama, nine miles from Panama, a part of a rocky cliff was shaken down. At Cruces, midway between Panama and Colon, near the railroad, a stone church was literally shaken to pieces. As photographed by Mr. Demers, of the canal company, it shows a mass of ruins.

For miles the Panama railroad was useless. Track sunken, upheaved, for six miles between Baila Mona and Colon; the iron railroad bridge at Barbacoas, 608 feet long, was thrown out of line. The city and island of Colon suffered severely. A great fissure extended across the island, along the main street. Piles of lumber were shaken down, people thrown off their feet, etc. Subsequently a fissure was discovered extending along the Chagres river. Its length was stated to be two miles. It varied in width from a few inches to several feet, closing below in abysmal darkness. Shocks of a less violent nature continued for several days. Minor shocks continued at intervals for over twelve months. I have records of them by the dozen. Humboldt, in his travels, refers to the effect of earthquakes in Columbia. One authority on seismic disturbances states that an earthquake about a century ago destroyed 40,000 lives between Santa Fe and Panama. Immediately following the earthquakes of 1882, English scientists discussed the probable effects of such an earthquake on a completed canal, and argued that its banks would suffer severely.

COST OF THE WORK.

Five and a half years have passed since the landing of the first party of canal men at Colon. M. De Lesseps' engineering commission of 1880 stated that it would cost $168,000,000 to complete the canal, and that a cube of 75,000,000 of cubic meters would have to be removed. M. De Lesseps in person reduced the $168,000,000 to $120,000,000, or 600,000,000 francs, placing the cost of the complete ditch at that figure. In January, 1885, it is stated that the company was owing 700,000,000 francs, or $140,000,000, to its share and bond holders, and that the interest on that sum was 22,875,000 francs, or say $4,500,000. Quite recently the *New York Times* placed the company's indebtedness at $166,000,000, and the annual interest thereon at $6,000,000. By many the scheme is considered a commercial impossibility, and that $400,000,000 or $500,000,000 will be necessary for its completion. Further, that if completed, no tonnage now known will pay even one-half of the percentum on such a fabulous sum. The cube was placed at 75,000,000 cubic meters. It is now known that fully double that amount, or 150 000,000, must be removed. The company's indebtedness has risen to $166,000,000, and less than one-sixth of the cube has been removed, accepting the company's figures as accurate.

M. De Lesseps recently referred to "France's peaceful conquest of the Isthmus," thus officially corroborating the statements made in a public speech at Panama by the Consul-General of France, who said: "France commenced the canal, France will finish it. French it is, and French it shall remain," or words to that effect. His speech was published in the *Star and Herald* of Panama.

Thus it seems that what was intended as a private enterprise in reality will end as a national undertaking that will place the "Gate to the Pacific" in the keeping of La Belle France.

COAL has been struck near Omaha, Neb., at a depth of 540 feet. The coal is said to be of very good quality, and the vein is four feet thick.

THE FRENCH WAR SHIP NEPTUNE

THE port of Brest was recently the scene of the launching of the Neptune, an ironclad, twin screw vessel of 10,500 tons burden, measuring 330 feet in length, 66 in width, and drawing 27 feet of water aft. Her two engines will be of 12,000 horse power with forced draught. She will be protected by an ironclad deck three inches thick, by a belt of armor plate of a maximum thickness of 17½ inches, extending from one end to the other of the float water line, and by a coffer dam filled with cellulose arranged at the extreme front. The turrets will be protected by plates 13¾ inches thick, and will be partially covered with a turtle back of steel, 2¼ inches thick, designed to protect the men and mechanism against musketry.

The artillery will consist of four 13¾ inch guns placed in the four barbette turrets, seventeen 5½ inch guns in the battery, ten revolving guns, and five torpedo launchers. The estimated speed is from 16½ to 17 knots.

The accompanying engravings show the arrangement of the various parts of the vessel. The net cost is estimated at about $3,000,000. The hull alone cost $2,000,000. According to custom, the launch was effected in the presence of the naval authorities and a large crowd.—*Paris Illustre.*

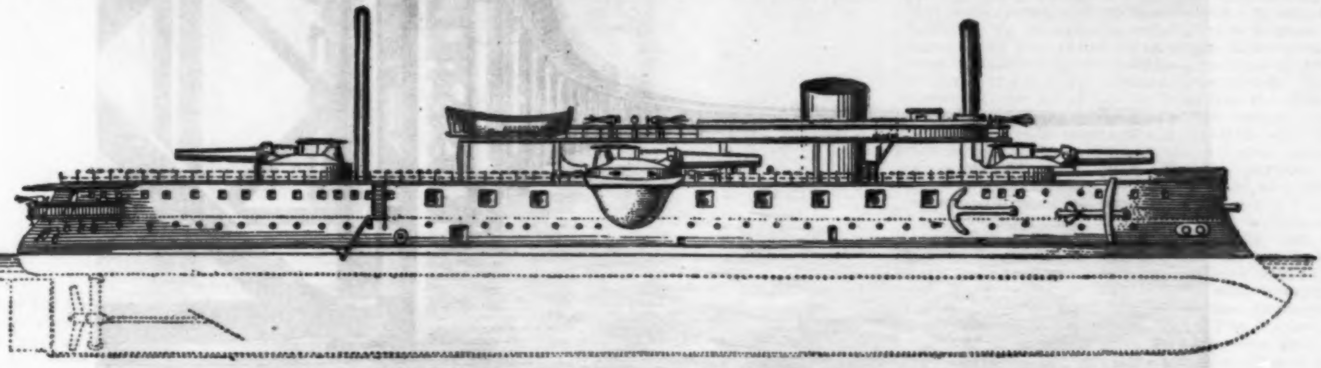


FIG. 1.—LONGITUDINAL VIEW.

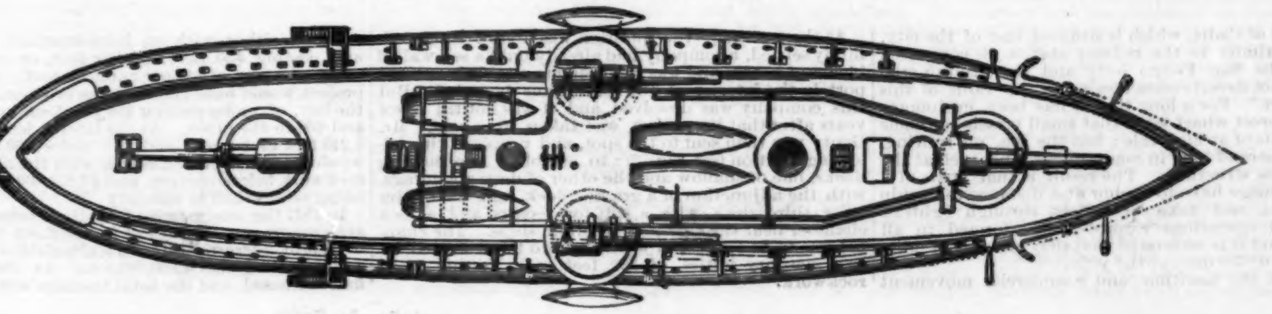


FIG. 2.—HORIZONTAL VIEW.

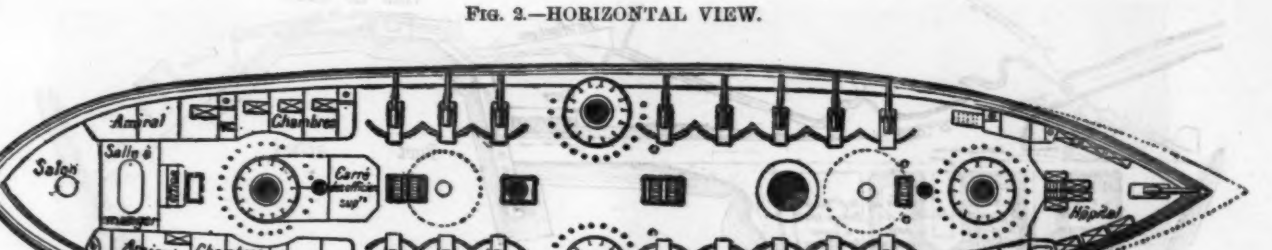


FIG. 3.—SECTION THROUGH THE BATTERY.

Scale, 0·002 to 1 meter.

THE FRENCH WAR SHIP NEPTUNE

THE PORT OF CADIZ.

IN the most southerly portion of the Iberian peninsula, bathed by the Atlantic Ocean, and separated from *terra firma* by a narrow channel, is situated the Isle of Leon, at the northern extremity of which stands the city of Cadiz. The city is seated on a mass of rock connected with the island by a narrow tongue of sand which runs sensibly S.S.E. by N.N.W., and which limits the famous roadstead of Cadiz. On the land side, the heights of the Trocadero loom up in the horizon, while toward the west there exists but one low coast, which is frequently swept by the sea breezes. The bay, which is of wide extent, offers a secure refuge to ships, and although at times, on account of its large dimensions, it becomes turbulent under the action of violent winds, such superficial agitation is not sufficient to affect the security of the vessels.

As for the movement of the water, that, however unlikely as it may appear, is scarcely known. It has not seemed useful to the engineers of the country to gather any statistical data regarding the ebb and flow, the nature or importance of the deposits that form, the situation or location of channels, etc. So when the day arrived on which it was desired to proceed to the work of repair, difficulties were encountered that would not otherwise have existed.

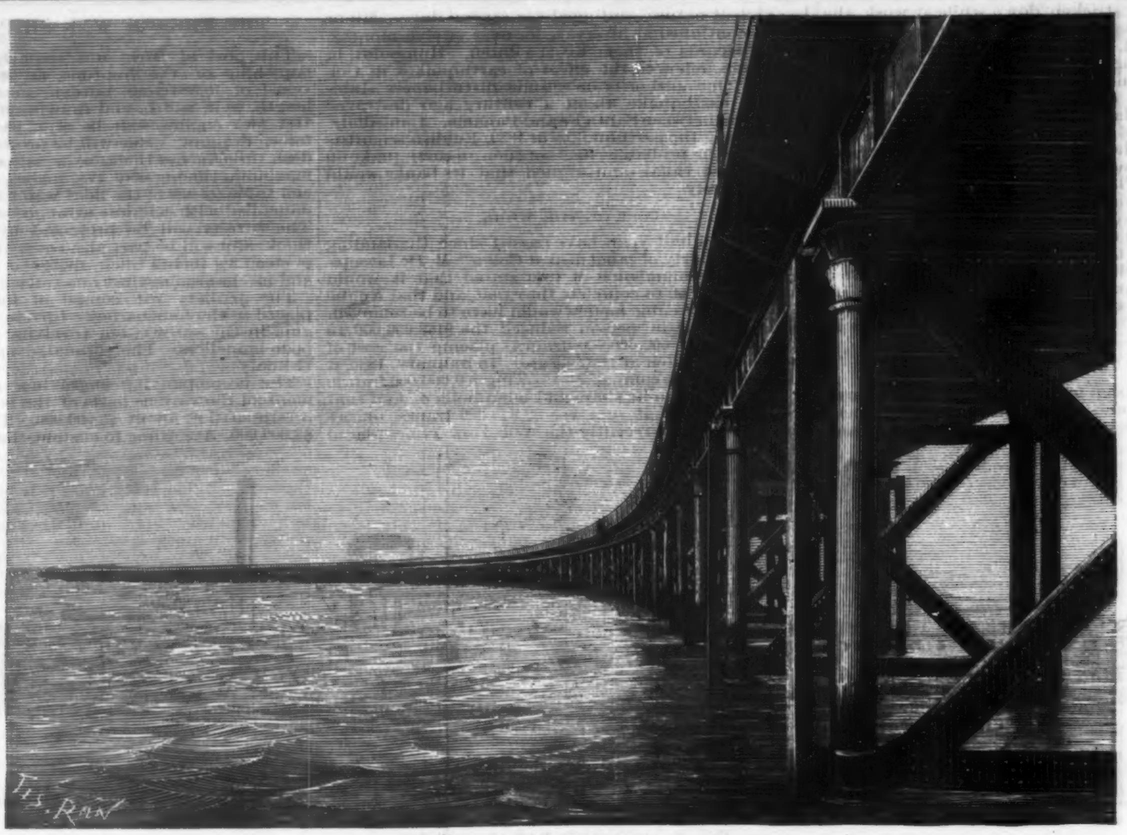


FIG. 1.—VIADUCT AND STOCKADE AT CADIZ.

The port of Cadiz, which is situated east of the city, and in proximity to the railway station, is comprised between the San Felipo jetty and the Capitainerie. We must not deceive ourselves as to the value of this word "port." For a long time it has been customary to merely erect wharf walls that small vessels can come up alongside of at high tide; but the sea, on retiring, leaves the strand bare in many places, and even at the base of these structures. The result is that boats of a certain tonnage have to anchor at a distance to unship their cargo, and take on freight through lighters. Now, such operations cannot be performed in all weather, and it is estimated that they are possible only during 240 or 250 days of the year.

A part of the maritime and commercial movement has shifted toward the Trocadero, where, however, nothing very satisfactory exists; and yet, in consequence of its situation, the bay of Cadiz is easily utilizable. This state of things had struck some quick minds, particularly that of a rich Spaniard, Mr. Diego F. Montanes, who, on dying, left a considerable sum to the city, with directions to have it applied to the following purposes: (1) to works for the distribution of potable water; (2) to the improvement of the port; (3) to the creation of a model farm; and (4) to the establishment of a naval college.

The legacy was left under certain conditions, into which we have no desire to enter; but in this way the money was at hand, and the work to be executed began to receive attention. Various projects were brought forward, only the principal of which—those of Mr. Genty—we shall examine.

At the moment the question was about being definitely settled, a company had already built a sea wall of blocks of beton, and was proposing to establish a closed port in the interior of the space thus bounded. But this company was dissolved, and it was not till a few years after that its project was taken up again. Mr. Genty was then sent to the spot, and proposed the following solution (see Fig. 2): to establish two floating docks, one of shallow and the other of deep anchorage, with the adjunction of a graving dock, and then, later on, a third dock, with a slip for repairs, and a lock chamber near the entrance to admit ships. The channel was to be 165 feet in width, and to be protected by two masonry jetties, of 328 feet each, resting upon rockwork.

The estimated cost was as follows:

Deep floating dock	$338,000
Shallow " "	270,000
Sluices	80,000
Lock chamber	41,400
Graving dock	124,000
Entrance channel	100,000
Filling in	104,000
Boats, houses, etc.	23,600
Personnel	75,000
Total	$1,156,000

Another project consisted in the establishment of a tide harbor by means of dikes inclosing a suitable space as regards area and depth; the jetties to be constructed either with an infrastructure of rockwork, and costing $30 per running foot, or entirely of masonry at a cost of $40 per running foot. Moreover, this project would have required the erection, at the side of the bay, of moles costing $50 per foot in the one case and $60 in the other. As the lateral jetties were to be 5,240 feet in length, and the moles 860 feet, the cost would have reached $2,390,000 with the adoption of the rockwork infrastructure, and $2,874,000 upon the whole being established in masonry

In 1877 the commerce of Cadiz represented, export and import, a movement of from 800,000 to 850,000 tons of freight, corresponding to a circulation of 5,750 ships, gauging altogether 1,600,000 tons. In 1880, these figures had increased, and the total tonnage was estimated at 2,000,000 tons, and the movement of freight at 1,000,000 tons. Since this epoch, the traffic has done nothing but grow, especially by reason of the improvements.

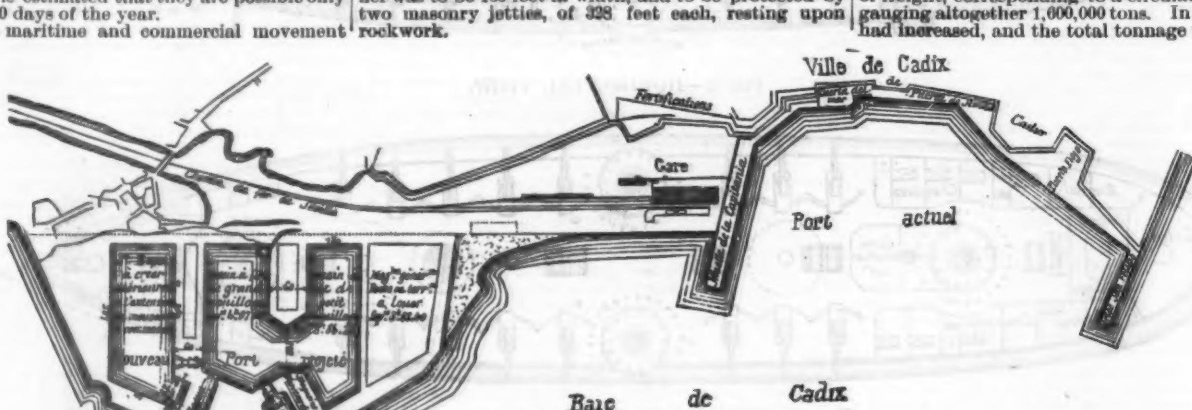
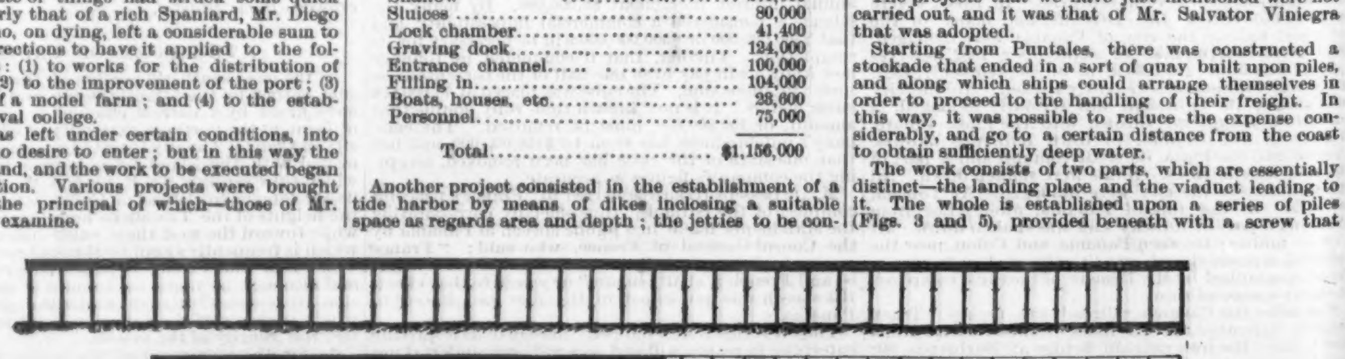


FIG. 2.—PORT OF CADIZ—PLAN OF FLOATING DOCKS.

The projects that we have just mentioned were not carried out, and it was that of Mr. Salvator Viniegra that was adopted.

Starting from Puntales, there was constructed a stockade that ended in a sort of quay built upon piles, and along which ships could arrange themselves in order to proceed to the handling of their freight. In this way, it was possible to reduce the expense considerably, and go to a certain distance from the coast to obtain sufficiently deep water.

The work consists of two parts, which are essentially distinct—the landing place and the viaduct leading to it. The whole is established upon a series of piles (Figs. 3 and 5), provided beneath with a screw that



FIGS. 3 AND 4.—ELEVATION AND PLAN OF STOCKADE.

permitted of sinking them in the sand without the necessity of erecting scaffoldings.

The putting in place was effected as follows: To the extremity of the part already constructed and provided with its superstructure, a steam crane was brought. By means of this, each pile (which carried at its lower part a drum around which a cable wound) was put in position at the place prescribed. The cable served to produce a rotation which caused the pile to penetrate the sand forming the bottom of the bay. The piles were sunk to a depth of from 3 to 12 feet, according to the consistency of the bottom, and in depths of water reaching 30 feet.

The components of the viaduct are as follows: (1) a straight part, 688 feet in length, formed of thirty-five bays, each having a span of 19¾ feet, and starting from the quay of Puntales; (2) a curved portion with a radius of 900 feet, of a length of 846 feet, and made up of forty-three bays equal to the preceding; and (3) a straight part 98 feet in length, composed of five bays of 19 foot span.

These bays serve to support a 155 foot wide platform; and a railway has been laid from the quay as far as to the end of the stockade, a distance of 1,633 feet.

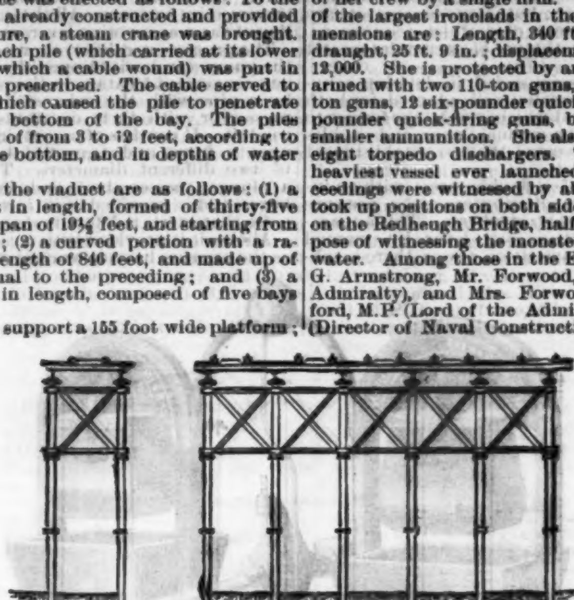


FIG. 5. Transverse Section of Viaduct.

FIG. 6. Transverse Section of Wharf.

As for the landing place (Figs. 4 and 6), that was constructed in the same manner as the viaduct, but, instead of two rows of piles, it includes six. The upper part consists of a platform 674 feet in length by 64 in width. The trains run chiefly on the three central tracks, while the two outside tracks are especially used for shifting the four cranes upon.

These latter have each a power of eight tons. There is also a stationary crane of twenty tons.

To construct this stockade, it took 6,600,000 pounds of metal, 39,695 cubic feet of wood, and ten months' time. The cost was $3,275,000.—*Le Genie Civil.*

FIG. 7.—VIADUCT AND STOCKADE AT CADIZ.

LAUNCH OF H. M. S. VICTORIA.

INTERESTING SPEECH OF SIR WILLIAM ARMSTRONG.

ON April 9 the armorclad war ship Victoria was launched from the Elswick yard of Sir W. G. Armstrong, Mitchell & Co., Newcastle-on-Tyne, by whom she has been built for the English government. Originally it was intended that the vessel should be named the Renown, but this was afterward altered and the name Victoria given to her instead, in honor of the Queen's jubilee. The first rivet in the Victoria was driven by Sir William Armstrong in June, 1885, so that she has been nearly two years in building, and nearly a similar period will have to elapse before she is ready for delivery. She will then, however, be in perfect fighting order, the firm which has built the vessel also providing her with all her armaments and machinery; this, we believe, being the first instance in which a war ship has been built and made ready for the reception of her crew by a single firm. The Victoria will be one of the largest ironclads in the British Navy. Her dimensions are: Length, 340 ft.; breadth, 70 ft.; mean draught, 25 ft. 9 in.; displacement in tons, 10,500; h. p., 12,000. She is protected by armor 18 in. thick, and is armed with two 110-ton guns, one 30-ton gun, 12 five-ton guns, 12 six-pounder quick-firing guns, nine three-pounder quick-firing guns, besides machine guns for smaller ammunition. She also has a powerful ram and eight torpedo dischargers. The Victoria being the heaviest vessel ever launched off the Tyne, the proceedings were witnessed by about 150,000 persons, who took up positions on both sides of the river, and even on the Redheugh Bridge, half a mile away, for the purpose of witnessing the monster craft as she took to the water. Among those in the Elswick yard were Sir W. G. Armstrong, Mr. Forwood, M.P. (Secretary to the Admiralty), and Mrs. Forwood, Lord Charles Beresford, M.P. (Lord of the Admiralty), Mr. W. H. White (Director of Naval Construction), Captain Noble, Mr. and Mrs. W. D. Craddas, the Mayor of Newcastle (Mr. B. C. Browne) and Mrs. Browne, the Vicar of Newcastle (Canon Lloyd), Canon Franklin, Canon Bromley, Colonel Potter, C.B., Captain Chapman, Professor Garnett, Mr. P. J. Messent, and several aldermen and councilors of Newcastle. The religious service with which the proceedings began was conducted by Canon Lloyd, who read the 107th psalm and three short prayers. The vessel was then launched by Mrs. Forwood, who, as she touched the apparatus for liberating the ship, christened her the Victoria, amid great cheering. The launch of the heavy vessel had the effect of throwing up a large wave on to the opposite bank of the river, where several people received a severe wetting, while not a few were knocked down by the force of the water. After the launch, the invited spectators adjourned to the mould loft, where refreshments were served.

Sir William Armstrong proposed the toast of "The Queen," after which he gave "The Royal Navy and success to her Majesty's ship Victoria." He said: The launch of to-day will be a memorable event in the history of Elswick, not only because the Victoria is the first armorclad that the company has built, but because she is the heaviest ship ever successfully launched in this country; for which reason the operation of launching was regarded as unusually critical. For my part, it was a great relief to see her safely in the water, and I trust her successful launch will be the commencement of a successful career. She has been honored with the name of Victoria, which, in this jubilee year, confers a high distinction on the ship, and she has been launched under the auspices of a lady who, I trust, will be as well satisfied with the success of the operation as all spectators must have been with her efficient performance on the occasion. I am about to propose a toast, but before I do so I will take the present opportunity of making some remarks concerning the Victoria and war ships in general. This is not a fitting occasion for me to criticise the policy of strengthening our fleet by the adoption of great armorclads rather than by the addition of swift cruisers of the protected class. I have said enough on this subject on many former occasions, and I will now only observe that I am glad to see that our Admiralty are disposed to slacken their expenditure on these gigantic ships in response to similar action on the part of other maritime powers, and that they are expanding their operations in the building of swift cruisers. I maintain, as I have always done, that this country requires above all things a numerous fleet of swift cruisers, not extemporized out of merchant or passenger ships, but specially built and adapted for the protection of the widespread commerce upon which our very existence depends, and for aiding in the defense of our colonies, which I trust will every year draw closer to the mother country. But what I chiefly wish to do on this occasion is to direct your attention to the marvelous transformation which has taken place within the last forty years in our ships of war and their armaments, and the enormous increase of efficiency which has been attained thereby. In an æsthetic point of view it must be confessed that our ships have sadly deteriorated. No more beautiful object could be seen than a great man of war of the old type under a press of sail. Poets and painters have delighted in depicting it. But the engineer appreciates power more than beauty, and while a Ruskin would stigmatize a modern war ship as a "devil" ship, the engineer regards it as a splendid triumph of mechanical skill. For the purpose of comparison between ships of the old sort and the new, I can take no more fitting examples than the Victory and the Victoria, so alike in name and yet so different in all things else. The Victory, I need hardly say, was the famous line-of-battle ship in which Nelson fought and died. She was one of the largest ships of her day, but her displacement or total weight with everything on board was only 3,500 tons, while the displacement of the Victoria will be 10,500 tons. The Victory, in accordance with the usage of the time, was built of oak. The Victoria, in accordance with the present practice, is built of iron. The Victory was propelled by wind, over which man has no control. The Victoria will be propelled by steam, over which man has perfect mastery. The Victory had the character of being an extraordinary quick sailer, and when the wind in its vagaries happened to be exceptionally propitious, she could attain a speed of nearly 13 knots an hour. The Victoria, propelled by engines of more than 12,000 h.p., may be expected to achieve about 17 knots an hour, and will be independent of the wind. In regard to armament, the comparison in favor of the Victoria is astounding, and ought to open the eyes of those who are in the habit of disparaging the progress of artillery in this country. The armament of the Victory as she fought at Trafalgar consisted of 30 32-pounders, 30 24-pounders, 40 12-pounders, and two 68-pounder carronades, making in all 102 guns. The heaviest of these guns was under three tons, while the heaviest on board the Victoria will be 110 tons. The largest charge of powder used on the Victory was 8 lb., while the largest charge to be used on the Victoria will be 900 lb. The heaviest shot used in the Victory was 68 lb., while in the Victoria it will be 1,800 lb. The weight of metal discharged from the broadside of the Victory was 1,150 lb., against 4,750 lb. from that of the Victoria. But the power of the broadside discharge of each ship is better indicated by the quantity of powder expended than by the weight of metal discharged; and while the broadside fire from the Victory consumed only 355 lb.,

that from the Victoria will consume 3,000 lb. In point of range, accuracy, penetrating power, and shell power, the difference is so great in favor of the Victoria that a comparison would be ridiculous. I have yet to give you the particulars of the Victoria's armament. It will consist of two 110-ton guns, mounted on a revolving turret and firing ahead or on either side; 12 five-ton guns, 12 six-pounder quick-firing guns, and nine three-pounder quick-firing guns, and a considerable number of machine guns for smaller ammunition. Besides her artillery armament the Victoria has a powerful ram, and she carries eight torpedo dischargers—four above water and four below water. In the fighting days of the Victory, ramming was little practiced and torpedoes were wholly unknown. Therefore, in these respects no comparison can be drawn. But there is another point of view in which the Victoria compares in a highly favorable degree with the Victory, and that is in the smallness of the number of officers and men required to handle and fight the ship. The complement of officers and men on board the Victory was 850, while on board the Victoria it will only be 550, of whom 110 will be engineers and stokers, leaving only 440 officers and men in a combatant capacity. Thus, although the Victoria is three times as big as the Victory, and prodigiously superior in offensive power, there will only be half the number of men exposed to death and wounds in the working of her armament. This result is chiefly due to mechanical appliances which in recent years have been introduced for working the guns. At the commencement of my career as an artillerist it was regarded as an axiom that no gun exceeding 5 tons weight could be worked on a moving platform such as the deck of a ship. A gun of 5 tons 12 cwt., firing a charge of 20 lb. of powder and a shot of 68 lb., has been tried on shipboard and found unmanageable, and it had to be replaced by a gun of 4 tons 15 cwt., firing only 16 lb. with the same weight of shot. At the present day we have to deal with guns of 110 tons, which have to be charged with powder and shot weighing together 2,700 lb. It is manifest that the loading and manipulation of such a gun could not possibly be effected by the manual labor of any number of men that could be crowded around the gun, but it has been effected by the employment of a very few men acting through the agency of hydraulic machinery invented and reduced to practice by the former Elswick Company, and largely covered by patents now vested in the present company. Then, again, to go from the largest to the smallest artillery gun to be used in the Victoria, which is the 3-pounder Hotchkiss quick-firing gun, we have another example of what mechanicians have done for artillery. It is a gun of great range and penetrative power, which by means of mechanical arrangements can be fired with deliberate aim twenty times a minute by the employment of only three men. Or, if we take the quick-firing gun which has recently been designed and perfected at Elswick, and which fires any desired weight of projectile between 30 lb. and 40 lb., and compare it with the old 32-pounder such as the Victory carried, and which required eight men to work it at the rate of one round a minute, we have in the new weapon a gun of enormously greater power, which can fire ten rounds a minute with only four men to serve it, so that this gun with four men to serve it will fire as many rounds per minute as could formerly be fired by eighty men with ten guns.

But while admitting, as all must do, the vast superiority of modern war ships over those which preceded them, you will probably say, "Look at their enormously greater cost and the burdens they impose upon the taxpayers." Now, I think there is a great deal of fallacy about the impoverishing effect upon the nation of this increase of cost; every penny spent upon ships of war is spent in the country, and every article used in their construction is derived from the natural resources of the country. The nation, taken as a whole, pays for its ships out of one pocket and receives the money into the other, and I do not see that it is much the worse for the operation. Much is said about the difference between productive and non-productive expenditure, but I fail to see how expenditure on war ships can be called unproductive when we gain by it protection from aggression on our coasts, our colonies, and our commerce. As well might we say that the vast expenditure on the piers at the mouth of the Tyne was unproductive, because we had nothing to show for it beyond the protection of our merchant ships from the violence of the sea. War ships are needed to protect us from the violence of our enemies, just as piers and breakwaters are needed to protect us against the violence of the sea, so that the economic aspect is the same in both cases. At all events, men want work in every department of industry, and additional outlay in any one department ramifies in every direction and indirectly benefits every other branch of industry. But I must not digress into political economy, but proceed to the main object of my rising, which is to propose the toast of the Royal Navy and success to the Victoria, coupled with the health of Mr. Forwood, the Parliamentary Secretary to the Admiralty.

Mr. A. B. Forwood, M.P., responded, and contrasted the state of the navy fifty years ago with its condition to-day. The figures he quoted ought, he said, to bring home to the people of the country the necessity of the expenditure that the country had at present to meet, and the necessity of maintaining our navy at the highest point of efficiency compared with the navies of other nations. He learned that the new vessel could remain at sea, at a high speed, for a distance of something like 5,000 knots, or very nearly the distance from here to New York and back. While he believed it was necessary to keep the naval dockyards fully employed, he approved the system of allowing the extra vessels to be built by the private firms of the kingdom. He concluded by proposing "Success to the Elswick firm."

Sir W. G. Armstrong replied, and stated that the firm had recently completed a swift cruiser for a foreign government, which, on being tried, attained the speed of $19\frac{1}{2}$ knots an hour, and was thus the swiftest cruiser afloat.

JARDIN'S HYDRAULIC PRESS AND INJECTION PUMP.

THE substitution of the hydraulic press for the screw press for the extraction of oils is now nearly complete. Aside from the advantages that it possesses, as regards facility of maneuvering, it is much appreciated for the rapidity with which it gives a very strong pressure, this being an indispensable condition for the prevention of the oils being retained by the cake.

In most small oil works, the injection pump is actuated by manual power; but plants of some size are all provided with a steam motor, which requires, according to circumstances, the use of accumulators and pressure regulators.

Mr. Sylvan Jardin has succeeded in devising a hydraulic press which is equally well adapted for both small and large works, and which enables the former to substitute horse power for manual labor, and enables the latter to reduce the cost of the first establishment to a considerable degree.

Fig. 1 shows a model of a double press with an injection pump having two distributers and a pressure gauge graduated up to 300 atmospheres. This apparatus is maneuvered with a long lever by manual power. In works that have steam power, there is substituted for this pump the one shown in Fig. 2 with its self-gearing regulator to the left.

It may be remarked that the columns that are usually used to connect the cross piece with the press cylinder are here replaced by an iron ring forged in a single piece, owing to which the pressure exerted upon all the parts of the apparatus thus rendered interdependent is distributed uniformly.

This arrangement has the further advantage of requiring no foundation.

Whatever be the mode of actuating the pump, it is provided with a safety valve, and with cut-offs with posphor-bronze points that take the place of ordinary valves, the use of which with high pressures is attended with some inconveniences.

An inspection of Fig. 2 will show how the steam pump is arranged. The valve box of this apparatus merits attention, and in Fig. 3 we give a section of it.

It will be seen that the tube, B, that connects the box, A, with the pump cylinder is cast in a piece with the box, and that the latter is provided with a boss, F (in which is held, by a nut, the flange of the force pipe, G), and a lateral piece, C, that supports the lever of the safety valve. The suction valve, H, is screwed to a brass rod, I, which is connected by a transmission with the regulator described further along. At J is a force valve, which, like the preceding valves, has its head traversed by a groove. All these parts, with the exception of the maneuvering lever, are of phosphor-bronze.

The pressure regulator, shown in Fig. 2 alongside of the pump, can be fixed upon the latter or be placed in any convenient location in the works. It is connected by a pipe with the exhaust of the pump, with the presses, or with their distributers, through a second conduit. It consists of a cast iron cylinder mounted upon a frame and traversed by an iron rod turned to two different diameters. This rod, which forms a plunger, passes above and below through stuffing boxes, and is provided at its lower end with a counterpoise that exerts a determinate resistance.

Above, it is provided with a cast iron head. As long as the pressure has not reached its maximum intensity, the counterpoise remains immovable; but, at the moment that it is about reaching this point, the cylinder rod rises and lifts an iron weight suspended from a chain, which, through guide pulleys, descends vertically, and is hooked to the counterpoise of the automatic gearing of the pump. Since the chain slackens by reason of being lifted by the head of the cylinder rod, it allows the gearing counterpoise to descend, and thus determines the lifting of the suction valve from its seat, and consequently the pump's running empty.

When the pressure lowers, the regulator counterpoise redescends, as does also the chain weight, and the chain lifts its counterpoise, and the latter, taking its initial position, lowers the lever of the valve and allows the latter to fall on its seat.

The water under pressure is sent into the presses by means of a special distributer, shown in section and elevation in Figs. 4 and 5, as arranged for use with two apparatus.

This distributer consists of a cylinder, with which is cast in a piece an elbow that connects it with the regulator, and that contains a $\frac{3}{16}$ inch aperture through which the water arrives under pressure.

This water distributes itself throughout the central

FIG. 1.—DOUBLE HYDRAULIC PRESS.

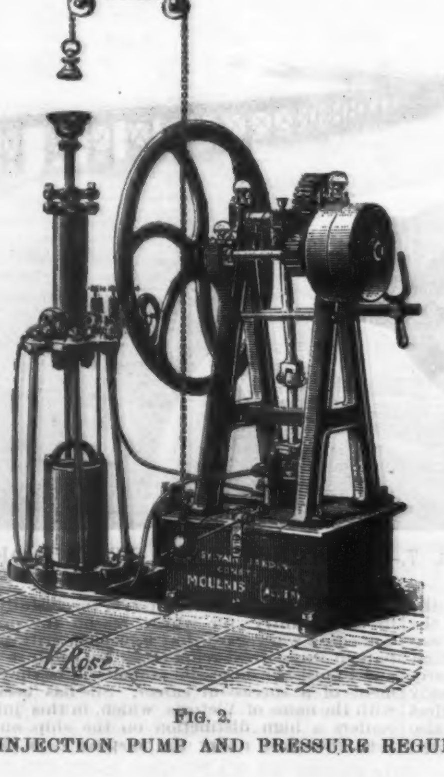


FIG. 2.

FIG 2.—INJECTION PUMP AND PRESSURE REGULATOR.

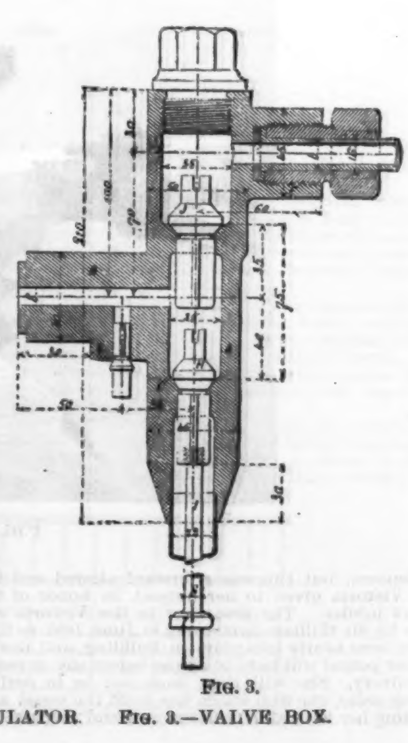


FIG. 3.

FIG. 3.—VALVE BOX.

channel of the apparatus, from whence it is forced to the presses by pipes, J, mounted in nuts and held by their collar, c, which presses upon the leather, c.

Either of the pumps may be stopped at will, or both at once, by means of the screws, C, which are maneuvered by means of hand wheels. These screws terminate in a point that can be applied against a seat in front of the orifices through which the water is forced, so as to isolate them from the conduit under pressure.

In order to obtain a hermetical junction, these screws are made to traverse the nuts, I, screwed up against the leather washers, b.

When the operation is terminated, and it is desired to turn the water of the presses into the reservoir of the pump, the upper screws, A, are maneuvered by means of winches until their pointed ends leave the apertures, k, whence start the $\frac{1}{8}$ inch discharge pipes. In Fig. 5, it will be seen that the discharge holes, k, are plugged at k' by two threaded bolts.

All the parts of this distributer, save the hand wheels, winches, and pipes, are of phosphor-bronze, and are sufficiently strong to be capable of operating under a pressure of 300 atmospheres.—*Revue Industrielle.*

THE CYCLE AND THE ROAD.*

By the Rev. J. M. TAYLOR, Beaconsfield.

THE first principles laid down were:

1. In pedestrianism the locomotive value of each act of self-propulsion is limited to the length of the steps or strides of the limbs.
2. Such limitation is due, in part, to the necessity of carrying the load as well as of propelling it.
3. A cycle, or wheeled vehicle rolling on a plane, has a weight-carrying power of very high value.
4. The locomotive powers of the human body, when applied to the cycle on such a plane, yield locomotive results far greater than those which the pedestrian has at command.

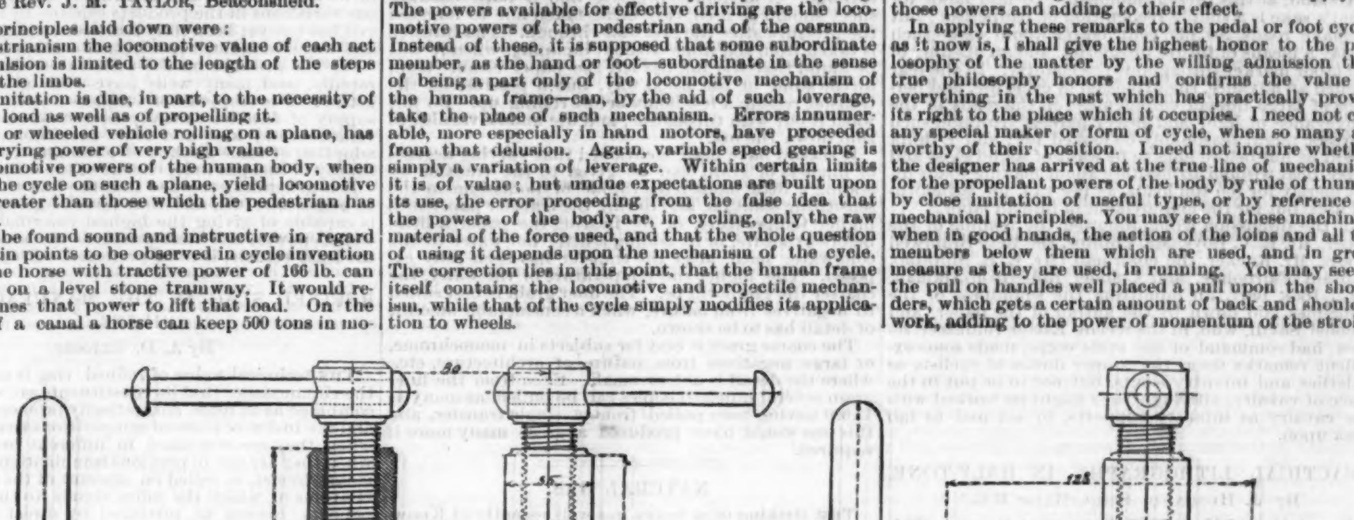
These will be found sound and instructive in regard to all the main points to be observed in cycle invention and use. One horse with tractive power of 166 lb. can draw 8 tons on a level stone tramway. It would require 100 times that power to lift that load. On the still reach of a canal a horse can keep 500 tons in motion for hours. These extreme cases show, in principle, how great is the difference in the power required, when in one case it is required simply to propel a load, and in the other to propel it by lifting it in part or wholly. How important a matter is the comprehension of principles appears at once from the instances thus given of the extraordinary value of tramways or canals as contrasted with the makeshift common roads of this country, on which 17 cwt. is a one-horse load, even when carried on wheels.

Thus, an underestimate of the powers available for riding leads to too great attention to lightness and so to weakness of construction, and to the reduction of the size of steering wheels, and expenditure of a large amount of the driving force in vibration consequent on such reduction. Again, some machines are described as enabling riders to drive by their weight as an addition to their muscular force. An accurate knowledge of elementary mechanics would check such misstatements, and prevent purchasers from being misled by them. Weight is a useful form of applying muscular force, but no more. It requires to be wound up by muscular force after each expenditure.

I aim in this paper at fixing sound principles in the mind by familiar illustrations, being assured that by being made matters of interest to the mind, they will get a firm hold upon it, and abide there in full force and practical use. A mischievous notion is that enormous leverage can be made available for driving easily. In practice, if a man introduces it between the hand or foot and the gearing, he has to undo it all between the gearing and the radius of the driving wheel. In principle it confounds statics and dynamics. It confounds the means of putting or placing a mass with the dynamical use of power in giving traveling or projectile velocity to that mass. A form of this error involves abandonment of a first principle in cycling. The powers available for effective driving are the locomotive powers of the pedestrian and of the oarsman. Instead of these, it is supposed that some subordinate member, as the hand or foot—subordinate in the sense of being a part only of the locomotive mechanism of the human frame—can, by the aid of such leverage, take the place of such mechanism. Errors innumerable, more especially in hand motors, have proceeded from that delusion. Again, variable speed gearing is simply a variation of leverage. Within certain limits it is of value; but undue expectations are built upon its use, the error proceeding from the false idea that the powers of the body are, in cycling, only the raw material of the force used, and that the whole question of using it depends upon the mechanism of the cycle. The correction lies in this point, that the human frame itself contains the locomotive and projectile mechanism, while that of the cycle simply modifies its application to wheels.

high speed, the scores of miles which can be quietly traveled by elderly men, whose feet would be worn to exhaustion on foot after a fraction of such distances—these are facts realized, and, so to speak, outdone, year by year. I have not traveled more than 24 miles myself in the day, but with 15 stone to carry and a machine which at that time weighed 168 lb., to say that I did not, on a journey of 16 miles, the day after, experience the smallest sign of stiffness or irritation in any member of the body is a fact which entitles me to claim a place for my invention. It also plainly indicates that on ways suitably prepared the cycle will be found as well adapted to heavy, useful work as to high speed. With the prospect of enlarged application of the cycle to useful purposes, it is, of course, most important to have the clearest understanding of the proper mode of using the bodily powers, in order to render them thoroughly available. Creatures which are superior to man in locomotive power are so because their whole bodily framework is a combination, in one point of view, expressly for that object. Man cannot, then, expect to improve his position in this respect by any use of hand or foot which does not apply and perfect the use of his largest bodily powers. Inventive skill would be thrown away which should seek to make hand power or foot power a substitute for his proper locomotive powers, instead of treating them as instruments for applying those powers and adding to their effect.

In applying these remarks to the pedal or foot cycle, as it now is, I shall give the highest honor to the philosophy of the matter by the willing admission that true philosophy honors and confirms the value of everything in the past which has practically proved its right to the place which it occupies. I need not cite any special maker or form of cycle, when so many are worthy of their position. I need not inquire whether the designer has arrived at the true line of mechanism for the propellant powers of the body by rule of thumb, by close imitation of useful types, or by reference to mechanical principles. You may see in these machines, when in good hands, the action of the loins and all the members below them which are used, and in great measure as they are used, in running. You may see in the pull on handles well placed a pull upon the shoulders, which gets a certain amount of back and shoulder work, adding to the power of momentum of the stroke.



FIGS. 4 AND 5.—DISTRIBUTER FOR TWO PRESSES

Different, indeed, is the stage of perfection now attained in cycle construction from that of the roads available to carry them. But we must not be content that this difference should continue. The machine is only one half of the matter. The road or way is the other half. We must not do things by halves. We must bear in mind that the prosperity of the country, as well as of cycling, is essentially connected with a sound system of ways suitable for transport and communication throughout the land. It will not suffice to improve, nor even to restore. The competition of foreign nations demands decided advance. Thus, instead of sending an engineer to ascertain whether a road in a certain locality is fit to carry a cycle, the report should be whether, in regard to foundation, material, sufficient and seasonable attention, it is fit to carry existing traffic with thorough economy winter and summer, but especially winter; whether the changes made in towns, under the pressure of necessity and of urgent local influence, are also carried out where the matter is out of sight, and out of reach of the immediate interposition of such influence. Nor would the enforcement of even these measures fully meet the business requirements of the times. The further question is, whether the ways, even of the towns, are, at their best, what they ought to be.

Cycling will confer an enormous benefit on the country if it brings back that sharp and efficient criticism to the roads which left them when men of business left them with the coaches. The position of the cycle with regard to sound principles is certainly that those principles are honored to a great extent. It does not follow that they are fully understood. It is certain that so far as they are not understood, fanciful ideas will come in, and prove the occasion for much trouble.

* Abstract of paper read before the Inventors' Institute, April 18, 1887.

For a most instructive typical illustration of the locomotive powers of the human body, I shall borrow from the gymnasium. The exercise of taking heavy weights from the floor, and making them travel upward till they are shot aloft above the head or shoulders, is a splendid form of action in momentum production. The pedalist and the oarsman may alike draw from this type of compound speed-producing mechanism. The line of its action, or, rather, the caliber of its action, lies between the shoulders and the feet, and is pre-eminently the line of power and locomotive force of the man. The double step of the Roman soldier on the march was 5 feet; the double step of the cyclist on wheels geared up to 60 is 5 yards. The action in the "Oarsman" tricycle is a close approach to that of the weight-lifting exercise of the gymnasium, or, in other words, the rowing action with the sliding seat. As the momentum-generating action of both legs is used together, it is a form of the standing jump with supplementary shoulder and arm lift. One such action suffices to carry me 20 yards from a state of rest. The long jump of the athlete is excellent at 20 feet, with the impulse of a short run. If I take the impulse of one quiet stroke, as a take-off run before my leap (on wheels), that 20 yards is doubled. I am not citing this as an instance of the superiority of the "Oarsman" over the many beautiful machines with pedal action. Its rank among others has to be tested by men of half my age and three or four stone less weight. Any cycle which can be put into a condition of high speed would cover many yards, if allowed at any moment to run out its course to a standstill. I am showing how thoroughly the weight-propellant action of the gymnasium is got into cycle form in my invention, that so large a result as 40 yards run should be got from the second stroke from the state of rest.

The principles which I have put forward in this paper, and illustrated so largely from artificial and natural forms of exertion, are abundantly verified in the cycles of the day, viz., that the locomotive mechanism of the human frame, when employed in the work of propelling only, and relieved of the office of carrying the load propelled, will yield results vastly in excess of those which are measured by the steps or strides of the pedestrian, when applied without such aid. The tremendous pace at which the cycle can be driven, the long distances which can be covered at

In the "Oarsman" tricycle I get the full spring from the foot pedals and rapid action of the shoulder, with a foot or fifteen inches of loin action by the use of the rocking seat. The arms are relieved of the heavier part of the work in the first part of the action, so that when the work comes light upon the hands they take it up with the more vigor for the rest afforded them; and as the road does not offer the resistance to high speed which is so astonishingly great in water, there is an extraordinary amount of life in a well arm-finished stroke, and a speed which no sculler could reach in water. It is a curious fact that the difference between conformity and disagreement with sound principle should lie in such simple matters as the position of a handle, a form of saddle, the distance of a saddle from a foot pedal, or the position of a foot on the pedal. But, in point of fact, they are all important matters.

In the "Oarsman" tricycle I get this principle of momentum so thoroughly carried out that no hand machine which has levers linked to cranks and driving wheels could expend it without jerking the levers out of the hands, and making them hammer most dangerously. I get an average of 12 yards to the stroke, and should therefore require wheels 12 feet in diameter, if the effect of the stroke were limited to a single revolution of the driving wheels. This shows how completely hand motors generally neglect the whole system of momentum generation in their construction, and the true locomotive line of force of the human mechanism. I am not here to deny them a field of usefulness; but it is their characteristic feature that, not using the dynamic mechanism of the human frame for generating velocity, they require constant application of force for slow motion. The "Oarsman" is free from the charge that the arms cannot take the office of the legs in driving for want of power. They do not take that office; direct driving from the rocking seat relieves them of it. It is a most powerful momentum generator. In ascending long gradients I use the arms less than when running at speed on the level. I have no arm-ache in 20 miles of riding. Good speed is attained with so low a rate of stroke that the wind is not pressed at all. I have run a mile and a half in seven minutes, with full ability to speak calmly. In running against two gentlemen on a "Sociable," I have called their attention to this fact. The manner of the stroke for a speed of 10 miles an hour is to begin to swing forward

slowly and deliberately immediately at the end of the stroke, and then, without any jerk, put the weight into the work from the stretcher (the foot pedals) with increasing rapidity to the finish. With such a mode of driving on a good, firm, level road, the work is wonderfully light, and the rush of the load is remarkable.

We are aided, in one point of view, in endeavoring to set on foot a thorough revision of our road communications, that they have come down to a very low point, indeed, and that agricultural depression is, at the least, materially enhanced by such a state of things. When it can be shown that a main road, sixteen miles from London, carrying (or failing to carry) very heavy traffic, is allowed to use a loam gravel 200 per cent. inferior to granite or its equivalent, and that half a mile further on better material is found unfit to maintain a level, true surface, we have a claim to be heard by the government of the country for the introduction of a new state of things. When we further bear in mind that railways from the seaport towns offer every facility to foreign competitors to get to our markets without the intervention of our antediluvian roads, our case is strengthened to the highest point of urgency and necessity. I need not say that the large employment of hands out of work, in a process of reconstruction, would be an enormous benefit to the country, and especially to Ireland, at this present moment. To find labor for labor's sake is a simple recognition of pauperism; but to make roads 200 per cent. better would make such outlay a means of future prosperity, and an opening of the labor market throughout the country. In the rear of such an advance, the extension of cycle use, and perhaps of large human employment on the roads in the conveyance of light and heavy parcels, fruit and such matters, might reasonably be looked for; and I think it will be felt before long to be want of sound sense and of political wisdom to hesitate about making roads fit, not merely for ten-ton loads, as per rail, for agricultural uses, but for the employment of human labor.

In the discussion which followed the reading of the paper, Mr. R. V. Boys, Mr. Phillips, the Rev. Bramwell Moore, Mr. Rucker, the chairman (Mr. E. R. Shipton), Captain Fairholme, and Colonel Robertson-Aikman, V.C., took part, all admitting the soundness of the principles laid down by the author of the paper; and Colonel Savill, who, in the recent Easter volunteer review, had command of the cycle corps, made some excellent remarks upon the proper duties of cyclists as orderlies and infantry scouts, but not to be put in the place of cavalry, although they might be worked with the cavalry as infantry supports, to aid and to fall back upon.

PRACTICAL LITHOGRAPHY IN HALF-TONE.

By J. HUSBAND, Sergt.-Major R.E.*

Description of Husband's Papyrotint Process.—This process has been named papyrotint, being a modification of Captain Abney's improved method of photolithography, named papyrotype. It is specially adapted for the reproduction of subjects in half-tone, such as architectural drawings in monochrome, or subjects from nature, and it is inexpensive. Its advantages over other methods of half-tone photo-lithography are, that a transfer can be taken in greasy ink, for transfer to stone or zinc, *direct* from any negative, however large, without the aid of a medium, the grain or reticulation being obtained simply by a chemical change. The transfer paper being in direct contact with the negative, the resulting prints are sharper than by those processes where interposed media are used; while the same negative will answer either for a silver print, platinotype, or a transfer for zinc or stone. The advantage of being able to use a non-reversed negative is very great, now that gelatine plates have so largely superseded those made with collodion.

The method of manipulation is as follows: Any good surfaced paper is floated on a bath composed of—

Gelatine (Nelson's flake)	8 ounces.
Glycerine	1½ "
Chloride of sodium (common salt)	2 "
Water	50 "

Great care should be taken that the solution is not overheated, and that the paper is coated without bubbles. It is then dried in a temperature of 60° Fahr. The paper will take about ten hours to dry, and in this state will keep for years. When required for use, it should be sensitized by floating or immersing in a bath of—

Bichromate of potash	1 ounce
Chloride of sodium	¼ "
Ferricyanide of potassium	100 grains
Water	30 ounces

This need not be done in the dark room, as the solution is not sensitive to light.

The paper, after sensitizing, is dried in a temperature of 70°, and in a dark room. When dry, it is exposed under any half-tone negative, in the ordinary printing frame. It is preferable to print in sunlight, and, for negatives of medium density, an exposure of three minutes is required; but the exposure will vary according to the density of the negative. The correct time of exposure can best be judged by looking at the print in the frame. When the image appears on the transfer paper a dark fawn color on a yellow ground, the transfer is sufficiently printed. It is put into a bath of cold water for about ten minutes, until the soluble gelatine has taken up its full quantity of water; then taken out, placed on a flat piece of stone, glass, or zinc plate, and the surface dried with blotting paper.

The action of the light has been to render the parts to which it has penetrated through the negative partly insoluble, and, at the same time, granulated. A hard transfer ink is now used, composed of—

White virgin wax	½ ounce
Stearine	½ "
Common resin	½ "

These are melted together in a crucible over a small gas jet, and to them are added 4 ounces of chalk printing ink, and the mixture reduced to the consistency of cream with spirits of turpentine. A soft sponge is saturated with this mixture, and rubbed gently over the exposed paper (in this stage the nature of the grain can be best seen). An ordinary letter-press roller, charged with a little ink from the inking slab, is then passed over the transfer, causing the ink to adhere firmly to the parts affected by the light, and removing it from the parts unacted upon. It will be found that with practice, rolling slowly and carefully as a letter-press printer would his form, the ink will be removed by the roller according to the action that has taken place by light, leaving the shadows fully charged with ink, and the high lights almost clear, the result being a grained transfer in greasy ink. The transfer is next put into a weak bath of tannin and bichromate of potash for a few minutes, and when taken out the surplus solution should be carefully dried off between clean sheets of blotting paper. The transfer is hung up to dry, and, when thoroughly dry, the whole of the still sensitive surface should be exposed to light for about two minutes. A weak solution of oxalic acid should be used for damping the transfer (about 1 in 100), and this should be applied to the back of the transfer with a soft sponge. After it has been damped about four times, it should be carefully put between clean sheets of blotting paper, and the surplus moisture removed. A cold polished stone is then set in the press, and after everything is ready the transfer is placed on the stone and pulled through twice. The stone or scraper is then reversed, and the transfer is again twice pulled through. A moderate pressure and a hard backing sheet should be used, care being taken not to increase the pressure after the first pull through. The transfer is taken from the stone without damping, when it will be found that the ink has left the paper clean. Gum up the stone in the usual way, but if possible let the transfer remain a few hours before rolling up. Do not wash it out with turpentine, and use middle varnish to thin down the ink.

It should have been mentioned that varying degrees of fineness of grain can be given to the transfer by adding a little more ferricyanide of potassium in the sensitizing solution, and drying the transfer paper at a higher temperature, or by heating the paper a little before exposure, or by adding a little hot water to the cold water bath, after the transfer has been fully exposed. The higher the temperature of the water, the coarser the grain will be. The finer grain is best suited to negatives from nature, when a considerable amount of detail has to be shown.

The coarse grain is best for subjects in monochrome, or large negatives from nature, of architecture, etc., where the detail is not so small. Even from the finer grain several hundred copies can be pulled, as many as 12,000 having been pulled from a single transfer, and this one would have produced a great many more if required.

* From the *Journal of the Photographic Society*. Reported in the *Photographic News*.

NATURAL GAS.

THE striking of a heavy gas well recently at Knowersville, near Albany, N. Y., brings the supply of this valuable fuel within measurable distance of a number of our great industries situated along the Hudson River. Each succeeding month brings new discoveries of gas nearer to New York, and recalls the prediction of Mr. Henry Wurtz, the eminent chemist, made seventeen years ago, that natural gas will be found in a belt following the outcrop of the great gas-bearing beds (the principal of which is the Marcellus shale), at such a distance from their outcrops as will give a depth of about 400 feet to the bed. Professor Wurtz, as long ago as 1869, urged the use of natural gas in the region of which the great gas well at West Bloomfield, Ontario Co., N. Y., was the center.

In a discussion before the Lyceum of Natural History of New York, October, 1871, he gave the quantity of gas sent out by this well as five cubic feet per second, and the composition eighty-two and one half volumes per cent. marsh gas, ten per cent. carbonic acid, three per cent. illuminating gases of the olefine group, estimated its heating power equal to fourteen tons of anthracite a day, and discussed at length the question of carrying the gas under heavy pressure to great distances for use as a heating and lighting agent. Professor Wurtz indicated five or six beds running across New York State, "lying deep enough, and thick and porous enough," to pour out combustible gas when tapped. And he repeated a statement he made long before editorially in the columns of the *Gas Light Journal*, that "it may be accepted with implicit confidence as a fact that there are vast districts of country throughout the United States in which, by judicious exploration, an immense number of such fountains of natural gas may be developed, furnishing a fuel which raises itself out of the mine, and which may be made to transport itself, up hill and down dale, to any point required, independently of seasons and circumstances, miners' strikes and railroad monopolies to the contrary notwithstanding. A future lies before this new art of developing the gifts of Mother Nature, big with a promise for which even the wondrous history of American petroleum production has furnished no parallel."

In conclusion, Professor Wurtz said: "I will venture to enounce as my own conviction, which, however visionary it may be deemed by many, I claim to be strictly founded on induction from known facts, that, throughout large sections of the United States (throughout the middle tier of counties in western New York, for example), every town, nay, every house in the land, ought to be both warmed and lighted by gas drawn from the bountiful bosom of Mother Earth, without money and without price."

Undoubtedly to this clear-minded and able chemist are due the first suggestions of the possibility of finding natural gas over great areas, and of carrying it to great distances for general manufacturing purposes. Yet it required fifteen years from the time when he demonstrated this before it actually received much attention, or was introduced on a large scale.

Many theories of the formation of natural gas have since been proposed, but it is none the less interesting to quote here that suggested by Professor Wurtz nearly seventeen years ago, in these words: "As to my views of the mode of formation of the gas that exists now in such enormous compression in these different strata, I ask, first, what *is* this gas chemically? Always essentially, from whatever horizon obtained, it is *marsh gas*, that hydrocarbon of all others which contains the most hydrogen and the least carbon, the compound which naturally and necessarily forms the final residue of the abstraction of carbon from organic matter by a powerful oxidizing agent, since in nature we scarce find elementary hydrogen as such a residue. Now, what oxidizing agents are there, or, rather, what have there been in all these rocks that could effect such a combustion? I reply, oxides of iron, now represented in these rocks by iron sulphides, showing the iron oxides to have passed through the forms of sulphates"—an action similar to that "evolution of marsh gas going on in every stagnant pool, loaded with vegetable matter, and blackened by sulphide of iron, which is occupied in conveying the oxygen of the water to the carbon of the mud."

The development of the natural gas industry during the past two years has been marvelous, yet it is almost as extraordinary that it required fifteen years after Professor Wurtz's prediction to awaken even enterprising men to what they all now know to be so incalculably important.

The use of natural gas is not, however, without certain drawbacks.

(1.) Marsh gas is the most rapidly explosive of all the hydrocarbon groups, and this has its effect, not merely in the form of greater danger in its use, but on its calorific power as a fuel.

(2.) The composition of the gas varies widely, even from the same well at short intervals of time, and this is certainly a very serious drawback, for when the gas is used with economy and intelligence, these variations in its quality may, and doubtless will, produce injurious variations in the products smelted by its use. This evil has not yet been fully realized, owing to the rough and wasteful manner in which this gas is being used.

(3.) The pressure on the wells varies enormously and rapidly, and many wells have even given out altogether. The stoppage of furnaces due to this varying supply of fuel has already caused not a little inconvenience and loss, and must inevitably lead to the adoption of some method of obtaining a supplemental supply of fuel gas independent of the wells.

It is generally conceded that the fuel of the future is to be gaseous fuel, and that form of gaseous fuel that is capable of giving the highest calorific intensity, as well as power, and that produces the most heat from the least volume, is to be preferred.—*Progressive Age.*

REFINED SLAG IN THE MANUFACTURE OF GLASS.

By A. D. ELBERS.

THE technical value of refined slag is mainly due to the circumstance that its constituents are so chemically combined as to more energetically promote the fritting and the fusion of mineral compositions than is the case when they are combined in different proportions, or when they are not in previous combination. *Singulo-* or *monosilicates*, so called on account of the quantitative relations in which the silica stands to the basic components, cannot be produced by direct methods, at least not for manufacturing purposes, but are produced in an impure condition, and in immense quantities, *as refuse or slag*. When such slag has been freed from the characteristic impurity, sulphur, which so greatly impairs its usefulness, and from matter which is not in constitutional connection, it becomes *refined slag*. The monosilicate constitution, as applied to the principal ingredient of the slag, is, in round figures, 35 per cent. of silica and 65 per cent. of lime; but when other bases are present besides lime, such as magnesia (MgO) and alumina, as is usually the case, the total silica of the refined compound is, in the average, nearer to 39 per cent.

The natural monosilicates of an approximating composition have either a large percentage of alumina, and then are not energetic fluxes, or have so much iron in combination that their use as a flux is restricted to the manufacture of those products in which such impurities are not objectionable. The peculiar advantage which can be derived from the use of a non-alkaline monosilicate flux, when it is sufficiently pure for such productions as that of colorless glass or of white china, is therefore not readily inferred from the behavior of any of the raw materials which have been thus far known, and much less so from the behavior of the crude slag in its vitiated sulphurous condition. The sulphur assists the formation, but also blunts the saturating energy of the formed slag, which is very fortunate for the lining of the furnaces in which the slag is produced, for refined molten slag makes very short work of the most approved fire brick, unless it finds some other silicious substance to act upon.

For the purpose of illustrating the proper functions of refined slag, the composition of good window glass affords an example. Such glass contains about 70 per cent. of silica, 13 per cent. of lime, and 17 per cent. of alkalies and incidental admixtures; its hardness and elasticity, as well as its resistance to acids, increase with the percentage of the silica and, as against alkaline and metallic bases, with that of the lime; but the refractoriness of the raw composition or *batch*, and the expense of melting or *boiling* it properly, increase in a similar ratio. These difficulties are lessened to some extent when the lime and a part of the silica—sand or pulverized quartz—which enter into the composition of the batch are already in chemical combination, as, for instance, when the natural bisilicate *wollastonite* is used, which contains about 52 per cent. of silica to 48 per cent. of lime. The wollastonite can be used in the above glass composition without raising the lime of the latter *above* 13 per cent., to the extent of about 27 per cent., and the refined slag can be used in the same manner to the extent of from 20 to 22 per cent. The wollastonite, however, though it melts quicker than quartz and lime, is more sluggish in the melted state, and does not assimilate readily with the rest of the melted mass, whereas the refined slag reacts so energetically that 5 to 10 per cent. of it has more effect on the state of fusion and assimilation of the total mass than 27 per cent. of wollastonite; or, to express it in another way, the same quantity of a compound, consisting of 13 parts of lime and 7 *parts* of silica, can dissolve *more than twice as much* of silica as that of another which is composed of 13 parts of lime and 14 *parts* of silica.

This saturating energy of the *monosilicate* is similar to the *force of motion* by which a stone can be broken with *one* blow, when two strokes of half the power could not break it; for the bisilicate compound, which is obtained by melting refined slag and quartz, is just as sluggish in its behavior when it is remelted with more quartz, or with other ingredients of the glass batch, as natural bisilicates of corresponding composition.

For economical reasons, refined slag cannot be used to any larger extent for the composition of ordinary glass batches, in which crude and cheap alkalies are employed, than that in which its efficiency for reducing the expense of the *process of boiling* is an equivalent for its cost, and that proportion will, presumably, not average above 5 per cent.; but in compositions in which it can be used to replace, in part, refined alkalies, borates and oxides of lead, which exceed its cost by from fifty to four hundred per cent., its substitution to the fullest possible extent is as well a question of economizing in first cost as of improving the quality of the ware it is destined to produce.

These replacements are of especial importance in glazing and enameling pottery, which, being used for culinary purposes, is liable to become corroded by the action of fatty acids; but, apart from this, the fritting energy of refined slag makes it particularly serviceable in pottery manufacture. It induces a more thorough combination, by less firing, of the usual components of the bodies, from the first porcelain down to fire brick, and in new and more advantageous proportions. These facts have all been experimentally tested and approved by leading practical manufacturers in almost every branch of the industry.

The only theoretical objection which can be made to the use of refined slag in the manufacture of glass is that as glass which contains *several* non-alkaline bases is, usually, more liable to devitrify than that which contains only *one*, a multiplicity of bases would be introduced with the refined slag, which contains lime, magnesia, and alumina. The results of many tests which have been made in that direction—the compositions having been melted in a porcelain kiln in which they had to cool very slowly—do not indicate that magnesia and alumina, in those small proportions in which they are thus introduced, have any such tendency, nor is it quite certain that devitrifaction in general is owing to the nature or *kind* of the substances which have been combined, rather than to the *state of combination* in which the substances were *before* they became absorbed in the new compound. It is certainly evident that the magnesia and alumina of the monosilicate must assimilate more thoroughly with the mass than the same substances do when they are derived from a sluggish compound, or from one which only dissolves at a more advanced stage of the boiling.

Hoboken, New Jersey, May, 1887.

—*Eng. and Min. Jour.*

DIFFUSION PLANT FOR CANE SUGAR.

WHILE the system has been applied to the production of beet root sugar for a considerable number of years, it has only recently found extended application in the cane sugar industry, and it will no doubt be of considerable interest if we lay before our readers the general arrangement of a plant designed by Mr. R. Riedel, of the Hallesche Maschinenfabrik, Halle a./S., Germany, who has identified himself for many years with the sugar industry, and has built a large number of sugar works at home and abroad.

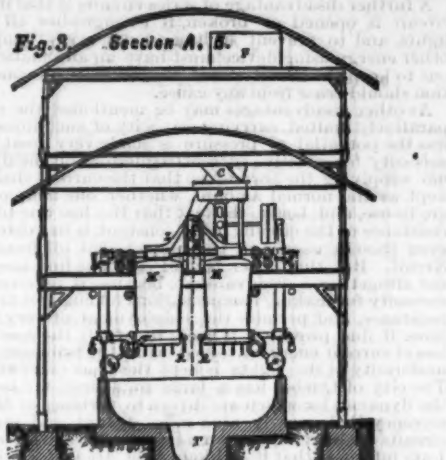
In the arrangment shown by our illustrations on the present page, the bundles of cane are brought to the elevator, A, and by this are lifted up to the staging erected above the cutting machine, B. The latter is fed by means of three funnels, C C C, set at a suitable angle to a horizontal disk fitted with cutters, so as to cut elliptical slices off the cane. The circular knife or cutter disk rotates at a high speed, and produces, according to the shape of the knives, either flat or corrugated slices. The latter form is generally preferred, since it prevents the individual slices from adhering to each other, and insures them offering large extracting surfaces to the water. From the cutters the sliced cane falls upon an endless carrier, D, consisting of a broad band, E, carried and driven by two large end rollers, F, and smaller intermediate rollers, K. This band travels along the bottom of a trough, H, which has openings in the sides, closed by slides and placed opposite to the diffusing vessels, M. By placing barriers across the trough and opening the corresponding slide at the side, each one of the cistern diffusing vessels can be filled with sliced cane. When full the vessel is closed and water is turned on from the reservoir, P, the water being, however, previously heated in a heater, O, one of which is provided for each diffuser.

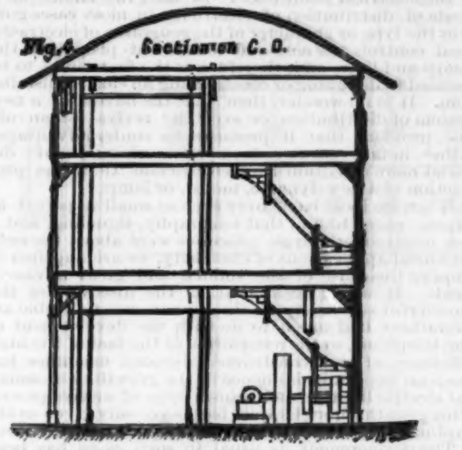
The mode of operation when the battery is in full swing is as follows: The fresh water enters that diffusing vessel which has already been in operation longest, and the contents of which will first be emptied. The fresh water thus displaces what may be termed weak sugar solution. This travels over to the next vessel, there extracts what is left, and gradually becoming concentrated, meets in every fresh vessel slices more fully charged with sugar, while the solution following this is still capable of extracting what the preceding solution left behind. The process may thus be considered a continuous one, in which each vessel in its turn becomes the first and the last of the series. In passing from one diffusing vessel to the next, the water, or rather sugar solution, is taken in each case through the steam heater, O, and at last after completing its travel it issues in the form of pure rich sugar solution into the concentrating pans. Here it is treated in the same manner as the juice obtained from the crushing rolls. The cane slices are emptied from the diffusing vessel, containing but a fraction of one percentage of sugar.

The diffusing vessels have at the top a large charging opening, closed by a cover and rubber joint, by means of a saddle piece and bolt fitted with a handwheel. The bottom of the vessel, which is cylindrical, and about 3 ft. in diameter by 5 ft. 6 in. high, is hinged and held by a vacuum clip, R; a balance weight, S, is provided to facilitate the handling of the apparatus. The bottom joint is made by means of a tubular rubber ring, bedded in a groove made in the bottom flange of the vessel, and open toward the bottom. When the cover is closed, water is forced into this ring at a pressure of about 20 lb. This arrangement, which is found to make an excellent tight joint, is the invention of Mr. Dautzenberg, and has proved very successful.

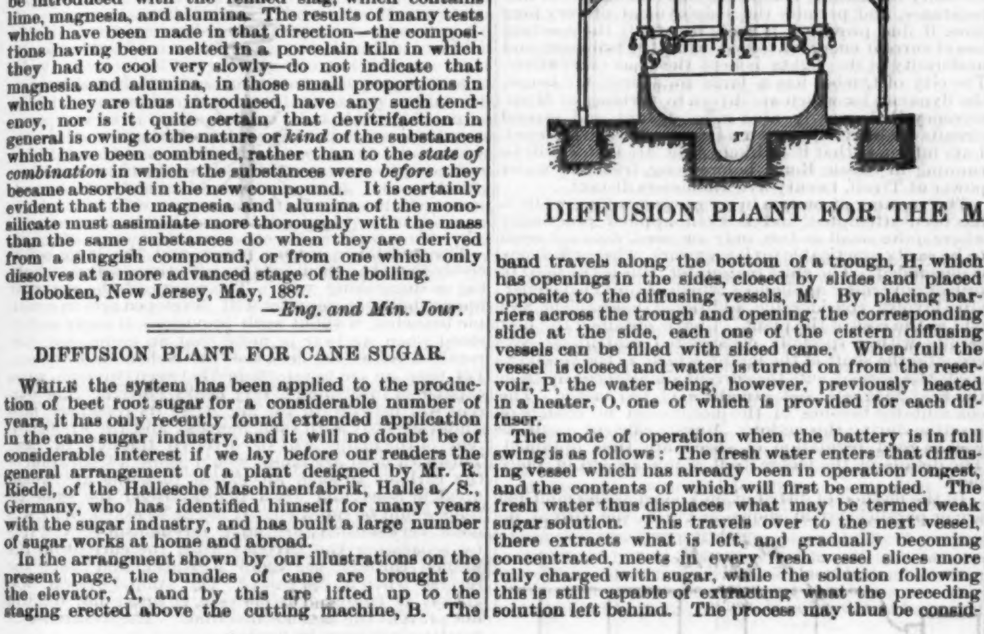
The cistern diffusion vessels shown in this battery are of ample dimensions to deal easily with 300 tons of sugar cane in twenty-four hours, while in many cases even a smaller plant will give as good or even better results. It is evident that with a larger number of vessels a more complete extraction of the cane can be effected, and the resulting juices are of a higher concentration, but experience has shown that it is more economical to be satisfied with less concentrated juice and less complete extraction, rather than to leave the water in contact with cane slices for too long a time, since the quality of the juice deteriorates if the process be too much prolonged.

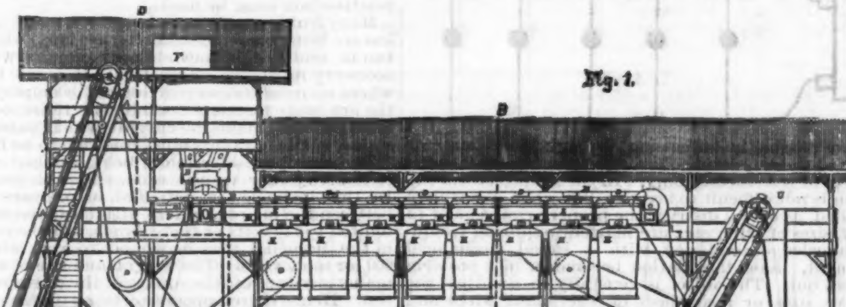
Below the diffusing vessels a brick-lined trough is provided, into which the residue is discharged, the bottom of the trough being sloped and the end closed by a strainer. The water runs off while the cane slices remain; these are picked up by the perforated hoppers of the elevator, U, and loaded into trucks to be air dried, or they are passed through a press to separate the water from them and then directly used for fuel in furnaces of the Four-Godillot or other types. In well arranged sugar factories, where the concentration of the juice is carried out in vacuum pans of most improved pattern, and where otherwise heat is economized in a rational manner, little or no fuel is required in addition to the residues. The Hallesche Maschinenfabrik also arranges diffusion plants on a circular system, which in many places is preferable in consequence of scarcity in room.—*Engineering.*

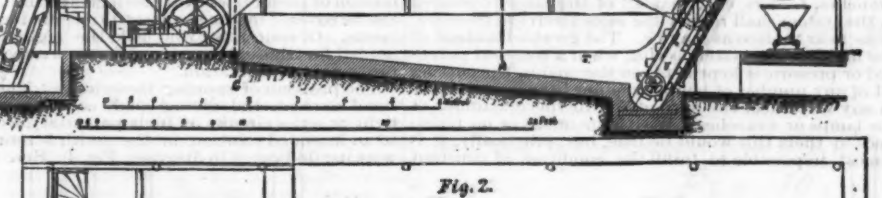




DIFFUSION PLANT FOR THE MANUFACTURE OF CANE SUGAR.



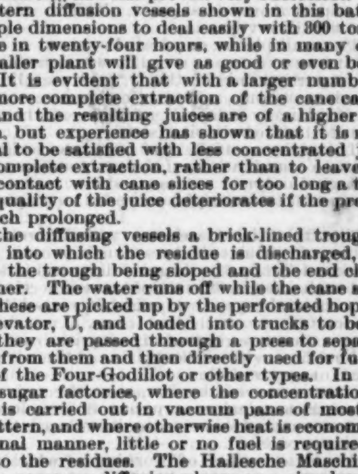




DIFFUSION PLANT FOR THE MANUFACTURE OF CANE SUGAR.

ELECTRIC LAMP FOR DIVERS.

AT the Newcastle Exhibition Mr. R. Applegarth shows a number of submarine appliances. An object of interest is the electrical lamp shown in the accompanying sketch. This consists of a brass casing, A, containing an incandescent lamp of about 100 candle power, which is screwed into the upper sight hole of the helmet. The casing has a reflector at back and a glass in front, so that a strong beam of light is reflected at an angle from above downward, so as to illuminate the object without dazzling the diver. Wires to the lamp are taken from a dynamo above.



ELECTRIC LAMP FOR DIVERS.

SIBLEY COLLEGE LECTURES.—1886-87.

BY THE CORNELL UNIVERSITY NON-RESIDENT LECTURERS IN MECHANICAL ENGINEERING.

V. SYSTEMS OF DISTRIBUTION OF ELECTRICITY.

By ELIHU THOMSON, of Lynn, Mass.

IN choosing as a subject for the present lecture, "Systems of Electric Distribution," I was influenced partly by the fact that, to the electrical engineer, the ways or methods of conveying electrical energy to different points, or of causing it to be evolved at such points, with the requisite characters to make it useful for lighting, for power, etc., are sometimes of as great, if not greater, moment than the exact type or construction of the electrical plant itself. In fact, the choice of a mode of distribution of electricity in most cases governs the type or character of the generator of electricity used, controls the cost and convenient placing of the lamps and lines, and, therefore, is the first thing to be decided in designing or constructing an electric installation. It is no wonder, then, that the advent of a new system of distribution, or even the revival of an old one, provided that it promises to confer advantages either in first cost or economy of working, should demand more attention from electricians than the production of a new dynamo, motor, or lamp.

When we look back over even so small a period as fifteen years, to find that telegraphy, signaling, and a few electro-metallurgic processes were about the only technical applications of electricity, we are impelled to inquire the cause of the sudden and great advances made. It would seem that, as the discovery of the wonderful sensibility of the human ear to feeble air vibrations had much to do with the development of the telephone, so the recognition of the fact of the high efficiency of well constructed dynamo machines has been an important influence in the growth of economical electric lighting and transmission of motive power. This growth, though rapid, has as yet only given us the sapling. Who shall witness the fully developed tree?

The development, as usual in such cases, has been the result of interaction between ends to be accomplished, means at disposal, and difficulties to be overcome; and the difficulties to be overcome have not been at a minimum when the problem of distribution of electric energy over considerable distances has been attacked.

It is easy to make a *general* classification of the modes or systems of distribution at present in use, though in reality no sharp distinctions can be drawn between them, as they are often variously combined to form mixed systems.

We may enumerate these as follows:

1. The series system, or a system in which the current sent from a generating station or apparatus passes through all the lamps, motors, or resistances connected into a series, one after the other, and at distances apart more or less great. This is also called a single wire direct system.

2. The multiple arc or parallel system, in which the current branches from two main wires through smaller wires, a portion only of the current supplied passing through each lamp, motor, or resistance; so that each branch is largely independent of the others. It is also called the derived circuit system.

3. The series multiple and multiple series systems, which are combinations of the two foregoing.

4. Accumulator or storage systems, as extensions of either series, or multiple, or series multiple arrangements.

5. The induction systems, in which currents in one conductor or primary coil are caused to induce currents in a second conductor or secondary coil, and as combined with a series or multiple arc connection.

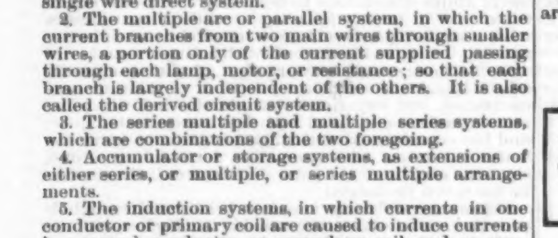
Any one of these systems might, if treated thoroughly, consume far more time than is now at our disposal.

I must therefore content myself with brief references to interesting matters illustrative of the advantages or disadvantages of each.

The list comprises by no means the only modes of delivering electrical energy, but it is believed to be sufficiently comprehensive to include all the systems practically worked.

In the series system of working (of which Fig. 1 is a diagram), we have the advantage of great simplicity

Fig. 1.



in arranging the wires or conductors, for it is only necessary to place the conductor in the form of a single line from the dynamo or source of current and back; into which line we may insert arc lamps, incandescent lamps, or motors up to the capacity of the dynamo or up to the amount of its power to force the current through one lamp after another, so to speak.

As is well known, nearly all the arc lamps in use are installed on the series system, the number of lamps placed in series being sometimes over sixty. I have known instances in which more than one hundred and twenty have been run for weeks upon one line with good results, but on acount of the very high electromotive force (6,000 volts nearly) demanded to sustain the current, and the danger of leakage and shocks, such practice is not to be recommended.

In one instance within my knowledge such a circuit, of about one hundred and twenty lamps, was successfully operated, notwithstanding the fact that the wires passed about a large city, and that one set of dynamos were at one part of the city and another set at a different point, and both sets run in series upon the same line. Such a circuit of lamps represented from 80 to 90 H. P. of electrical energy delivered, and included many miles of conductor. The disadvantages of the series system of working are several. In the first place, the arc lamps, incandescent lamps, or motors require to be adjusted to carry the line current when giving their normal light or work—no more, no less; a condition which practically forbids the use of various sizes or powers of arc lamps on the same circuit, which imposes upon the incandescent lamp maker conditions not easy to attain, and which limits greatly the applicability of motors to such lines. It is not easy to construct self-governing motors for series lines which shall have the virtues of great simplicity and economy. Incandescent lamps of various candle powers are, however, being rapidly introduced, suited to circuits with standard currents of 6·8 and 10 amperes, and in company with arc lights on the same circuits. Series circuits are even run for series incandescent lamps alone.

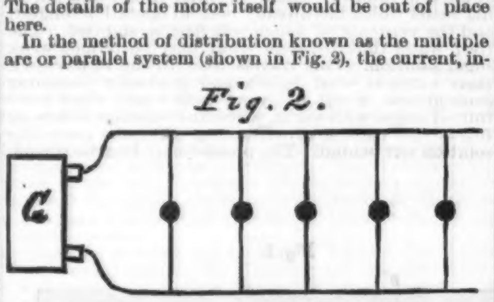
A further disadvantage of series circuits is that if the circuit is opened or broken, it extinguishes all the lights, and to prevent such accidents, every lamp or other energy-using device must have an automatic cut out to keep the circuit closed around it, if its conduction should cease from any cause.

As other disadvantages may be mentioned the comparatively limited carrying capacity of such lines unless the potential or pressure is made very great, the necessity for sensitive current regulators on the dynamo supplying the current, so that the current shall be kept at the normal amount, whether one lamp or all are in use, and, lastly, the fact that the loss due to the resistance of the circuit, being constant, is in existence, even though nearly all the lamps be cut off from the circuit. But this latter fact of constant line losses is not altogether a disadvantage, because it removes all necessity for making compensations for changes in line resistance, and permits the employment of very long lines, if due provision is made to supply the constant loss of current energy involved, while the brilliancy and uniformity of the lights is kept the same everywhere. The city of Quebec has a large number of arc lamps, the dynamos for which are driven by turbines at Montmorency Falls, nearly nine miles distant, and several circuits of about thirty-four miles of wire each are used. I am informed that it is likely that arc lamps will be running in classic Rome before long, from the water power at Tivoli, twenty-five kilometers distant.

The running of motors in series upon a line, while it has been attempted, and is even applied practically where quite small motors only are used, does not seem to be easily practicable for larger work, where efficiency is demanded. The chief reason for this is the need of proper governing appliances, which, if provided, generally involve considerable additional mechanism, and add to the cost of the plant. I have obtained the best results with a specially constructed centrifugal governor on the shaft of the motor, which, as the speed exceeds the normal, cuts the current simultaneously from the field magnets and armature of the motor. The commutator brushes of the motor need no change of position during this action. A quite efficient result, as well as good regulation of speed, are thus obtained. The details of the motor itself would be out of place here.

In the method of distribution known as the multiple arc or parallel system (shown in Fig. 2), the current, instead of passing in succession through each lamp or motor of the set, divides through them, so that each receives of it a fraction only. In the simplest form the system is not difficult to arrange, but when it is widely extended, as over a district, the proper arrangement to adopt, sizes of wire, etc., are matters requiring technical knowledge combined with a sound mechanical judgment. Each installation becomes a new problem to work out. The object is generally to so adjust the relative sizes or resistances of the main wires and branches, feeders, etc., that all of the lamps operated in the system shall receive the same electrical pressure, or as near thereto as may be. The great advantage of the multiple arc system is that when a constant potential or pressure is kept between the mains, the cutting off of any number of lamps or minor branches does not in any way affect the current fed to the remainder of the lamps or branches. With large mains or no resistance in them this would be true, but, practically, it is almost impossible to fulfill the condition of constant

Fig. 2.



potential or electric pressure at all parts of the system of mains, at moderate cost. The best we can do is to effect as near an approach to that equalization as possible.

It is needless to say that the early large installations of incandescent lamps have been made on the parallel system, either in its simple form or in modifications thereof.

The disadvantage is the large and sometimes prohibitive first cost due to the low potential or pressure of current used, which is limited by the difficulties of constructing incandescent lamps demanding more than 100 to 110 volts potential, and this demands that the wiring or circuits, to secure economy of conveyance of current to the lamps, must contain a large amount of copper, or, what is the same, the conductors must be made of large section. The simple multiple arc system is now nearly confined to isolated plants of incandescent lights, in which the lights are within 500 to 800 feet from the dynamo. For lighting mills and other buildings by a dynamo on the spot, it leaves nothing to be desired; but for distribution over a district in a city or town, the cost of the needed conductors limits the distance which can be covered.

The multiple arc system and its modifications, permit economy under light loads, or with few lamps in use, as the loss on the mains is then near the minimum.

Attempts have frequently been made to work arc lamps in multiple arc, either with other arc lamps or with incandescent lights. While moderate success may be achieved by using sensitive mechanism to control the carbons of the lamp, and by causing the arcs to burn as short arcs (that is, practically semi-incandescent lights), the running of arc lamps of the type known as *long arcs*, or perfectly developed arcs, arcs sufficiently long to burn without frying or hissing, appears to be impracticable unless a considerable resistance or a large reactive coil (a coil of copper wire wound on an iron core having a high self-induction) is inserted into the branch containing the arc lamp (see Fig. 3).

Fig. 3.

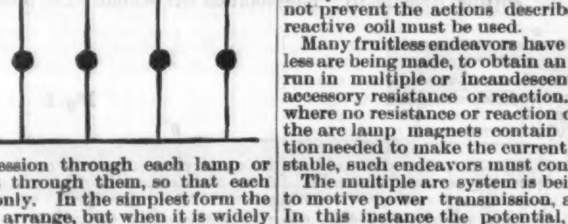
The resistance wastes power, and the large coil is costly to make. Such coils are sometimes called "choking or sluggishing coils." The reason of the apparent impossibility of running well developed arcs in multiple branches, without such provisions, is easily understood when we bear in mind that an increase of current in a voltaic arc decreases the resistance of the arc. Let, then, an arc be established between two main wires capable of furnishing a very heavy current. The current will increase in the arc, while its resistance falls simultaneously with such increase, and the whole current of the mains will be diverted through the arc. This with most arc lamps would cause a separation of the carbons to such an extent that the arc would break or cease, and when re-established the same actions would be repeated. It might be asked, Why will not a very sensitive arc lamp mechanism control this by separating the carbons when the current in the branch through the lamp increases, and doing the reverse when it decreases? The lamp, however, will always be behind time in its compensations, and will not prevent the actions described. The resistance or reactive coil must be used.

Many fruitless endeavors have been made, and doubtless are being made, to obtain an arc lamp which should run in multiple or incandescent circuits without the accessory resistance or reaction. It is safe to say that where no resistance or reaction coil is employed, unless the arc lamp magnets contain the resistance or reaction needed to make the current which passes the arc, stable, such endeavors must continue to be fruitless.

The multiple arc system is being applied extensively to motive power transmission, and with great success. In this instance the potential, or pressure difference between the mains, is not as with incandescent lighting limited to 110 volts or thereabouts, but the motors used in the branches may be wound to work with 200, 400, 600, or more volts. The weight and size of wire for the mains is reduced as the square of the pressure or potential. Hence there appears to be no obstacle to the extension of power lines over much greater distances than can be covered by the simple multiple arc incandescent mains. Of course, to avoid leak, the higher potential needed for this extension requires corresponding improvement in insulation.

The problem of running incandescent lamps using a small current, and giving small candle power, on arc light or series circuits of high potential has given rise to an intended solution in the multiple series mode of working (indicated in diagram, Fig. 4). Here the lamps

Fig. 4.

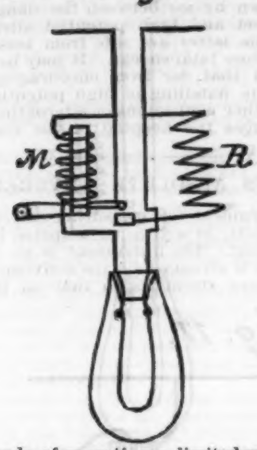


are grouped in multiple in numbers sufficient to allow the line current to pass in the branches. Thus, if the line current is 10 amperes, 10 lamps, each requiring one ampere, might be used, forming what we may call a group, and such groups may be repeated on the circuit as needed.

They may be run in series with arc lamps, or a number of such groups may be placed in a circuit without arc lamps. Both modes of placing are used to a considerable extent in practice, and where the groups are properly installed, the plan gives excellent results, but for the best economy has, of course, the disadvantage of requiring that all the lamps in a group be allowed to remain alight, and also the disadvantage of their being placed upon circuits the potential of which is so high as to require extra precautions against leaks and

shocks. An additional disadvantage lies in the necessity for providing what is called a distributer (such as Fig. 5), or a device which substitutes an equal resistance for an unused lamp or for one whose filament breaks, so to preserve the balance of current divided or distributed to the other lamps of the group.

Fig. 5.

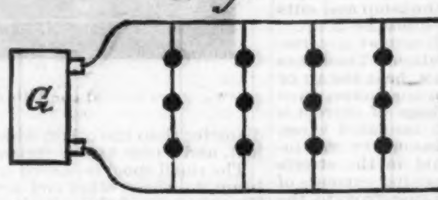


Another mode of operating a limited number of incandescent lamps on arc light circuits is to use such lamps in branches or shunts around the arc lamps of the circuit, diverting a portion of the current from the arc lamp, and of course, lessening its light to some extent. When the incandescent lamps are selected to be equal in required pressure or volts, to that of the arc lamp, and when the regulating mechanism for the carbons of the arc lamp is sensitive, the incandescent lamp so used gives fair results and a good life. This plan is used in a number of places in Lynn, Mass., and in other places in stores where arc lights are in use, and where a few incandescent lights are wanted as desk lights. The fluctuations in brilliancy are much less than might be expected.

Another combination of series working with the multiple arc system, may be termed the series multiple system. In this the distribution is essentially a multiple arc system with series branches, while in the case of a multiple series line just alluded to, the distribution is essentially a series system of multiple or branched groups.

(The diagram, Fig. 6, shows the series multiple system.)

Fig. 6.



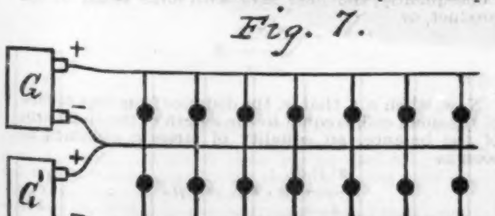
Here the branches in parallel joining the main conductors contain two or more lamps in series.

The only advantage in the running of a given number of lamps the use of less copper in the mains, because more lamps can be fed from a given main current, but the pressure or potential between the mains must be so much the higher as to overcome the resistance of a series of lamps in the branches instead of single lamps, as in the plain parallel or multiple arc system.

The series multiple system has been introduced and used in some cases with a fair degree of success, provided that all the lamps in any branch are required to be kept lighted together; but if any lamp or lamps are cut off from such branches, the proper brilliancy of the remaining lamps in the branch can only be maintained by substituting resistances for the unused lamps, and therefore consuming the same energy whether the lamps are alight or not.

The so-called three wire system is a modified multiple series system. It was adopted by Mr. Edison in order to effect a large saving (62½ per cent.) of the copper required in the plain multiple arc system. This it unquestionably accomplishes. It confers the power to run a multiple arc system with practically a series of two lamps of say 110 volts, in each branch between the outside mains, thus giving a pressure or potential of 220 volts between the outside mains. But in order to permit lamps to be extinguished in such a system without substituting resistances, and for saving power which otherwise would be consumed, a third wire or compensating wire is employed, joining the intermediate portions of all the branches, and giving rise to a multiple arc system as a whole, in series with another multiple arc system. If the number and power of lamps used in each multiple arc system so placed in series are equal, nothing further is required to be done than to connect the outer wires to a dynamo giving double the potential that each set of lamps in multiple requires.

Fig. 7.

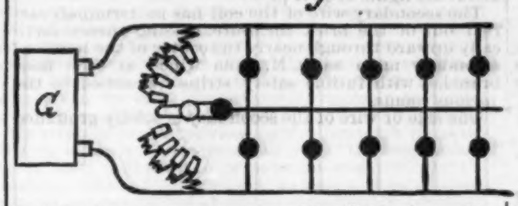


But if it is desired to take off and put on lamps in such a system *ad libitum*, then there is needed a means for effecting at all times either a balance between the two systems coupled or of rendering them capable of working independently.

The usual plan of working (Fig. 7) is to couple two matched dynamos to the mains in such a way that the compensator on middle main of the system is attached to the positive terminal of one dynamo and to the negative terminal of the other, while the other terminals of the dynamos are respectively connected with the other or outer mains of the systems. Each set of lamps may then be worked together or independently, and irregularity or inequality in number of lamps on the two sides of the system has little effect, since the output of each dynamo is in correspondence with the load or lamps used upon that side of the system to which it is connected.

Another mode of working is applicable to the case in which a single dynamo has its terminals connected with the outer mains of the system only. In this case (Fig. 8) the compensator or middle wire may be connected through resistances with the outer wires, or positive and negative mains respectively, the amount of which resistance can be varied.

Fig. 8.



The use of more or less resistance enables a balance of work to be effected, so that the two multiple arc systems have equal total currents flowing through them. This mode of compensation, involving, as it does, the use of resistances to be traversed by the current, is wasteful of energy and is not applicable economically to the case of considerable differences in the numbers of lamps in use upon the two sides of a three wire system.

A third mode of working (Fig. 9), by which a balance can be effected, and with economy of energy, is to employ a machine which transfers energy from the lightly loaded side of the system and delivers it to the heavily loaded side. Such an energy-transferring machine can be easily made. For example, a dynamo machine with an armature with two equal systems of winding and two commutators, the brushes of which are connected respectively to the two sides of the system, will, if properly proportioned, run as a motor at high speed, abstracting only a small amount of energy from each side of the system to keep it moving, when the two sides are equally loaded. But when they are unequally loaded, it runs as an electric motor by energy abstracted from the lightly loaded side and delivers current energy as a generator, to the heavily loaded side. The machine may be termed a continuous current inductorium whose primary and secondary wires are interchangeable and of equal size. In fact, with a three wire system using alternating currents it would be only necessary to use a good form of induction coil wound with two equal coils, one bridging from one main to the compensator or middle wire, and the other from the compensator line to the other main (Fig. 10).

Fig. 9.

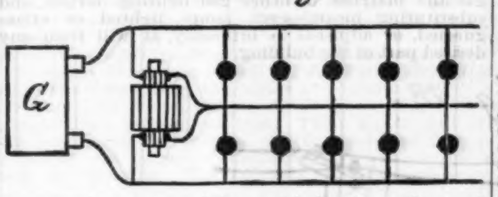
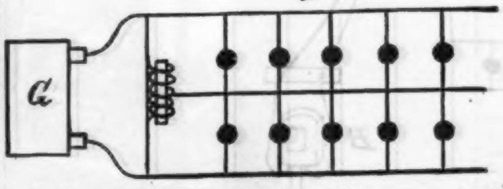


Fig. 10.



The action then is that either winding of the coil may become a primary inducing coil, receiving current energy from that side of the system having a slightly higher pressure or potential, and the other winding becoming the secondary induced conductor, delivering current energy to that side of the system which is heavily loaded or which has the lower potential or pressure. The experiments with such a system show that excellent compensation can be obtained in it. Alternating currents, however, offer to us other means of equalizing currents. We can use a substitute in place of lamps in alternating systems when it is desired to extinguish the lamps, and when their extinguishment might seriously affect the balance of work or current which ought to exist for preventing disturbance in the remaining lamps of the system. Such substitutes I term "reactive coil substitutes," and they may be made to waste very little energy in themselves, while fitting the condition of using a certain electromotive force and a certain current, the equal of those of the lamps for which they are substituted. The reactive coil substitute (S, indicated as capable of being used to supplant a lamp in Figs. 11 and 12) consists of nothing more complex than a single coil wound upon a core of iron wire or placed in a sheath of divided iron (S, Fig. 13). The coil is made of copper wire, which gives but a small resistance compared with that of the lamp whose place in the circuit it may occupy. The length of wire is such that the alternating impulses of electromotive force to which, as a lamp substitute, it will be subjected, just suffice to cause an average flow of current equal to that which normally would traverse the lamp. Its effects are those of self-induction, which limits the current passing, and virtually returns to the circuit a large per cent. of the energy received at every alternation. It is practically an absorbent of energy while the impulse of current in the alternating circuit is increasing, and a source of energy when the same impulse of current is decreasing.

Fig. 11.

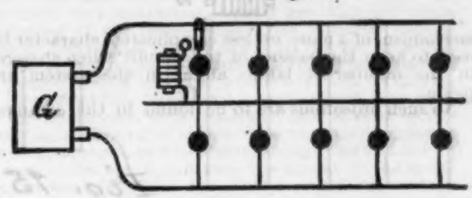
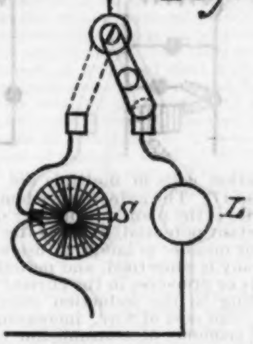


Fig. 12.



It is indeed surprising what a small coil if properly organized will supplant a lamp. The coil will not heat, and apparently uses the same electromotive force and current that the incandescent lamp did. It may be introduced into the circuit instead of the lamp without apparently affecting the conditions. But if a number of such reactive coil substitutes be used to supplant lamps in a system, there is a very evident falling off in energy consumed at the generator of the current.

Further, if an alternating current system or circuit be loaded with nothing else than reactive coil substitutes, or with a single sufficiently large reactive coil, efficiently constructed, the dynamo consumes a very small amount of mechanical energy, although it has at its terminals perhaps 1,000 volts potential and 20 amperes, a condition which, with continuous currents, means over 25 H. P. Indeed, with alternating currents it is possible successfully and efficiently to run incandescent or other lamps in series, or in multiple, or in multiple series, or in series multiple, or in other combinations and arrangements, provided that a "reactive coil substitute" be put in place of any lamp or lamps in the system which it is desired to extinguish. The energy consumed will fall off nearly in proportion to the lamps cut off, while the circuit arrangements, potential and current, at different parts will apparently remain unchanged.

There is not time to fully discuss this apparent paradox, but suffice it to say that the secret of the possibilities just pointed out is in the fact that *energy consumed* means a *certain position* of the *waves of current on the line* with respect to the *parts of the generating dynamo*, and energy *not consumed* is comparable with a *changed position* of the *waves* due to the *lagging* or retarding effect upon the impulses produced by the *self-induction* of the *reactive coils*, one or more. It is this difference from the actions of direct currents which stimulates the interest and enthusiasm of the worker with alternating currents.

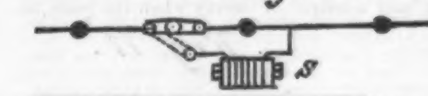
Fig. 13.

Powers are conferred upon the electrical engineer which are unknown in direct current working. The department of what may be called "electro-harmonics" becomes one of the chief divisions of the science of electricity. These considerations are also of great importance in relation to induction systems.

It is not my purpose here to touch upon the uses of the storage battery or accumulator as an addition to a system of distribution, because in reality the electricity may be said to have been distributed when it reaches the battery, where it takes the form of potential energy of chemical action, and in that form it has been distributed. It is a mere incident of the action that such chemical energy may again take the form of electricity—a convenient way, it may be said, of disposing of the battery; but, in view of the other matters in hand, it is hoped that such disposition may be acceptable under the circumstances. I may say in passing that I do not mean to slight the battery. Not at all. I believe that it is destined to become a generally used and useful electrical appliance.

We may now consider the system of distribution which employs induction coils as a means for changing the volume of current and its pressure, and also as a means for practically rendering the local lines of a building in a measure independent of the main or feeding lines. In the induction system, the induction coils, transformers, or converters, as they are called, may be used in series, or in parallel or multiple arc, or in a combination of the two. Their use in series is, however, not very easily practicable, unless reactive coil substitutes, S, before referred to, are used in place of lamps when extinguished (as in Figs. 14 and 15), or unless regulating

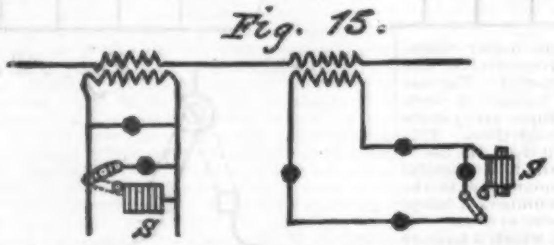
Fig. 14.



mechanism of a more or less complicated character be used to keep the balance of the circuit when changes in the number of lamps alight in the system are made.

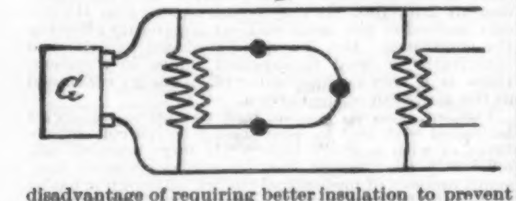
No such objections are to be found in the arrange-

Fig. 15.



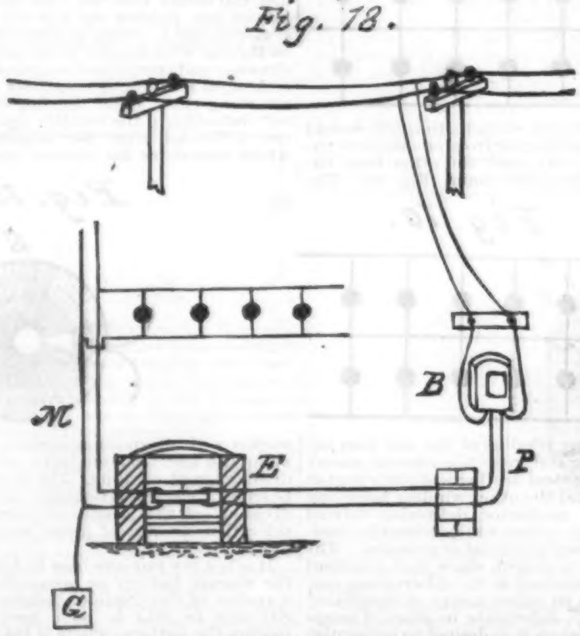
ment of the induction coils in multiple arc from the mains (Figs. 16 and 17). The induction system then possesses all the merits of the plain multiple arc or parallel system, with constant potential, so far as the ability to change the load or number of lamps in use with a corresponding economy is concerned, and permits the use of high potentials or pressures in the current sent out to the lines leading to the induction coils, thereby greatly lessening the cost of wire, increasing the distance over which economy of transmission can be attained, besides giving other advantages, with the sole

Fig. 16.



disadvantage of requiring better insulation to prevent leakages from the mains. In dealing with this system we cannot do better perhaps than to sketch briefly an existing installation. My house, with others in Lynn, is now lighted on the induction system, from the station of the Lynn Electric Lighting Co., a separate company from the Thomson-Houston Electric Co. The distance by wire of station from the house is about ¾ of a mile. A self-exciting alternating current dynamo, of much simpler and cheaper construction than is the case with continuous current machines, is driven by an engine used to supply the mains, which are run upon poles, and are of comparatively small wire. Branch wires from each main wire leave the pole line about 200

Fig. 18.



ft. away, and terminate in a small iron box (B, Fig. 18) at the back of the house, outside.

This box contains fuses or safety wires, which, in case of a short circuit forming in the wires leading from the box into the house, will, by fusing, cut off the branches of the main from all connection with the house wires. The box also contains a lightning arrester, which will allow a discharge of induced current due to lightning to reach earth. The box itself is grounded. The wires leading into the box are, of course, designed to convey alternating currents of high potential, and are therefore carefully protected against grounding. On leaving the box they continue their course through an iron pipe, P, from which they are very thoroughly insulated. This iron pipe passes through the wall, to the ceiling of the basement laundry, and thence to a small brick inclosure, E, into the interior of which the wires, 1, conveyed by the pipe, pass. These wires are there connected with the primary wires of an inductive coil, constructed for the purpose.

The secondary wire of the coil is much coarser than the primary wire, so that the induced currents in it are of not more than 50 volts average potential, and the volume obtained is capable of feeding forty 16 c. p. lamps, each lamp requiring about an ampere. The main line or primary line has a potential average of 660 volts and a capacity of over 30 amperes, capable of operating through the induction coils or transformers about 300 lights of 16 c. p.

The secondary wire of the coil has its terminals carried out of the brick inclosure, passing thence vertically upward through nearly the center of the house as secondary main wires, M, from which at each floor branches with fusible safety strips are carried to the various rooms.

One side or wire of the secondary is solidly grounded by an attachment to the gas and water pipes, G. This grounding or connection to earth of the secondary disposes of two elements of danger, *i. e.*, the danger of shock, which could exist when by accident a connection of the primary wire or high potential line to the secondary occurred, and the danger of lightning striking the line, breaking through the insulation of the coil, and seeking ground from the wires to the water pipes or gas pipes. However, as the box outside, before described, contains an efficient lightning arrester whose earth plates are also connected to the ground wires, the danger from the latter cause is nothing.

Provision is made with some of the lights to turn them up and down in brilliancy, which can be done with lamps run on alternating currents with a considerable saving of energy. In this case we use a modified reactive coil, a portion or the whole of which is, by a switch, introduced into circuit with the lamp and cuts down the impulses of current, and so dims the lamp.

Lights are turned off and on with almost a corresponding saving of power at the station. The lights are very steady, and of course do not heat the air or vitiate it. The potential is so low on the house wires that shocks are impossible, and leakage of current is easily prevented by the use of well insulated wires. Indeed, there would seem to be no reason why well insulated main wires may not be laid in the streets underground, adapted to carry alternating currents of 1,000 volts or more, branch wires run therefrom to the houses, where, in the cellar, is to be found, built in the wall, an iron or brick inclosure for the induction coil or transformer, for transferring electric current energy of high potential and small volume from the street mains to the local or house lines, in the form of low potential currents of large volume, doing away with gas and matches, or other gas lighting devices, and substituting incandescent lamps, lighted or extinguished, or adjusted in brilliancy, at will from any desired part of the building.

On account of the relatively great economy of transmission of high pressure or high potential currents, the lighting station for the dynamos can be placed where coal and water are easily obtained and condensing engines run.

With proper safeguards the system can be shorn of any great risks due to the use of alternating currents of high potential.

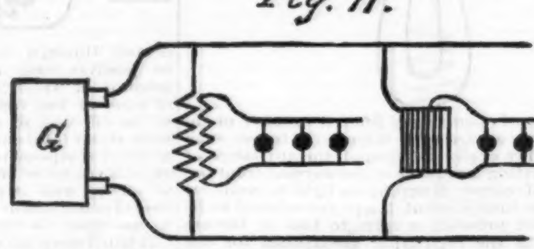
The fact is that alternating currents consisting of waves are, while modified or caused to lag by self-induction, comparatively free from the self-inductive actions found in continuous currents, and which prolong current or spark in any path taken by the current. Alternating currents do not tend to electrolyze moist insulation, and by disseminating copper salts from the wire into the moist insulation, make it a worse insulator.

Nevertheless, I do not wish to be understood as saying, as I fear has been in a measure the case, from comparisons drawn by me between the dangers of high potential direct and high potential alternating currents, that the latter are safe from leakage, or not liable to produce fatal shocks. It may have to be distinctly stated that, far from encouraging a lack of caution in the handling of high potential lines and current of either continuous or alternating character, the writer urges the keeping of the body on open circuit.

PELLAT'S ABSOLUTE AMPEREMETER.

A NEW instrument for measuring current strengths in C. G. S. units, as well as in amperes, has been invented by Pellat. The instrument is an electro-dynamometer, and is arranged for the convenient measurement of current strengths, so that an estimation of

Fig. 17.



current strength can be made by the use of gramme weights, thus enabling one to obtain the weight equivalent to the forces exerted in its passage through a wire by the current to be measured. Analogous instruments have often been employed in their investigations by physicists. As the diagram, Fig. 1, shows, the apparatus includes two coils, with axes at right angles to each other, one horizontal coil longer and of greater

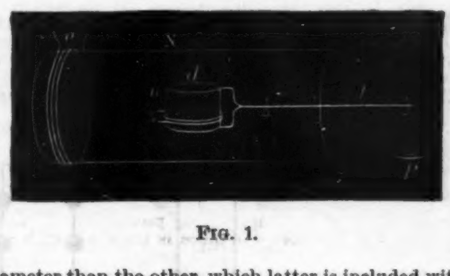


FIG. 1.

diameter than the other, which latter is included within it, and whose axis is vertical.

The small spool is carried by the short arm of a scale beam, to whose other end a weight pan is suspended. The winding of the coils is so arranged, by means of the standards of the balance, with reference to each other, that the current passes through both coils in succession.

This being the case, the smaller coil, which lies in the almost uniform electric field of the larger, strives to change the position of its axis; that is to say, tends to place its axis so that the direction of the current in itself shall be parallel to that in the larger one.

The measurement of the force developed by these tendencies of the coils, as effected by placing weights on the scale pan, gives directly the current strength, as will be explained in what follows.

Let p be the weight in grammes which is able to hold in equilibrium the force of the current, g the acceleration of the mass, l the length of the balance arm on which p acts, e the distance between the axes of two consecutive windings of the large coil, ε the same dimension with reference to the smaller coil, N the number of layers of wire on the larger coil, and n the number of windings of the small spool, all being in a single layer, d the diameter of the cylinder referred to the axis of the wire of the small coil as perimeter, and i the intensity of the current to be measured.

The intensity of the magnetic field excited by the large coil is expressed thus:

$$\frac{4\pi i}{e} N$$

whence the magnetic attraction of the inner coil as a solenoid for each face can be deduced, and is expressed thus:

$$\frac{\pi i d^2}{4\varepsilon}$$

Consequently, the field acts with force equal to the product, or

$$\frac{\pi^2 i^2 d^2}{e.\varepsilon} N$$

Now, when $n\,\varepsilon$, that is, the distance from face to face of the small coil, is equal to the length of the short arm of the balance, an equality of stress is obtained as soon as

$$\frac{\pi^2 i^2 d^2}{e.\varepsilon} n.\varepsilon N = g p l$$

whence

$$i = \sqrt{p}\sqrt{\frac{g l e}{\pi^2 d^2 n N}}$$

The factors following $\sqrt{p}$ maintain a constant value with the exception of g. Under similar conditions g is also constant.

If the dimensions are very accurately determined, the strength of current is given by the expression

$$i = \sqrt{p} \times \text{constant},$$

expressed either in C. G. S. units or in amperes (1 ampere = 0·1 C. G. S. unit).

The factor following $\sqrt{p}$ changes somewhat. If the limiting dimensions of the outer coil are given, then the value for the current intensity becomes

$$i = \sqrt{p}\sqrt{\frac{g\,l\,e}{\pi^2\,d^2\,N\,n\,(1-a)}}$$

in which a is a correction dependent on the length of the larger coil, which by calculation can be accurately determined.

The most essential problem is the construction of a normal instrument and the most accurate determination of the unitary dimensions required in the formula. It goes without saying that the solution of this problem is extremely difficult. In the normal instrument constructed by Pellat, the measurements were made partly by the international weights and measures bureau and partly by Pellat himself.

It is admitted that the relative error which can enter into the estimation of current strength by this instrument must not exceed $\frac{1}{1000}$; and it must be further noted that currents of 0·2 to 0·4 ampere are best suited for accurate measurement. The error then involved will be from 0·0001 to 0·0002 ampere.

The balance adopted in the perfected construction is shown in Fig. 3, and, to make the arrangement of parts more intelligible, the outer coil is broken away, so as to show the inner one. Fig. 2 is an accurate representation of the smaller coil and end of the balance beam. The connection of the winding of the small coil with that of the large one by means of the standards which carry the balance beam is effected by two fine spiral silver wires, of which one can be seen in front. The delicacy of the scales is thereby not at all impaired.

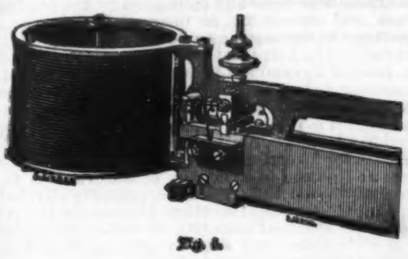


Fig. 2.

It is obvious that no part of the instrument can be made of iron or steel.

With regard to the sensibility of the balance, it is stated that it must show 0·1 milligramme. A current of 0·3 a. represents in Paris an equivalent weight of 0·418 gramme. The movements of the balance are observed by a microscope of low magnifying power, which can be seen in Fig. 3, whose eye-piece is provided with a grating or spider lines. For more accurate estimation of the equivalent weight, horizontal divisions marked upon the scale beam are provided for the use of the observer.

The influence of the magnetism of the earth is overcome by causing the movements of the beam to take place at right angles to the magnetic meridian. To exercise a perfect control over this, the current, after the balance has been brought into equilibrium, is allowed to pass through the movable coil alone, when no movement of the balance should be perceptible.

The aluminum used by Pellat in the construction of the cylinder of the smaller coil shows in the tests applied, in spite of the traces of iron, that the aluminum persistently retains so little magnetism that no unfavorable effects on the accuracy of the measurements could be detected.

An important and equally difficult determination is offered by the determination of the constant (C) of the instrument. The calculation gives 0·0498, while actual tests give 0·0495.

From the normal instrument made by Carpentier, Pellat proposes to construct copies for sale of the same construction, whose constant factor (C) shall be determined by measurements in comparison with the normal standard, and which then can be used for practical use in measuring electric currents, doing good service in adjusting ampere and volt meters.

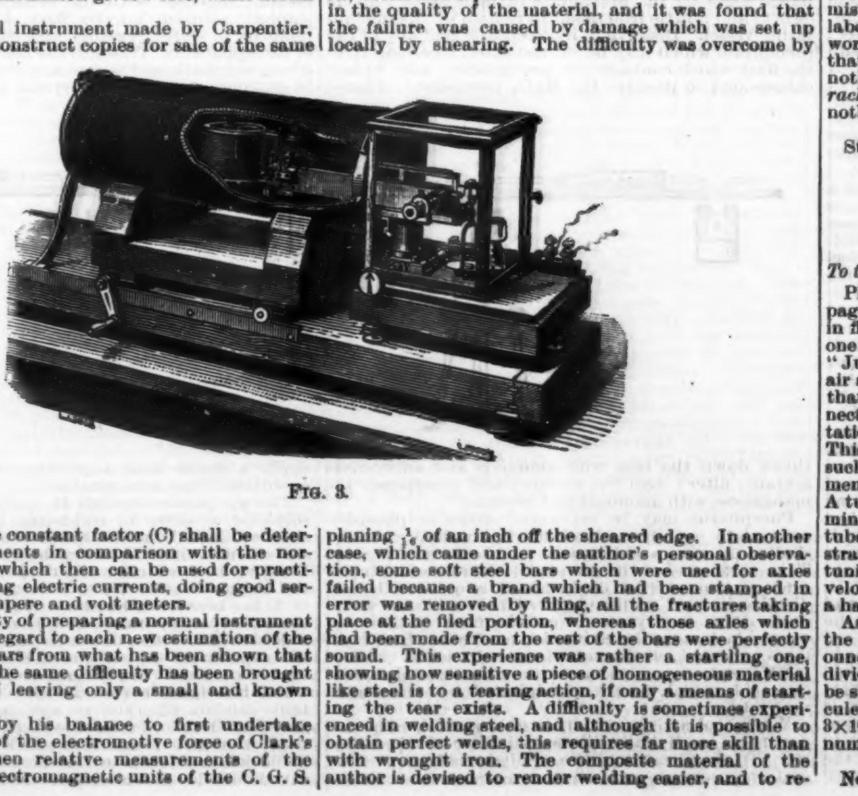


FIG. 3.

While the difficulty of preparing a normal instrument is very great with regard to each new estimation of the dimensions, it appears from what has been shown that the overcoming of the same difficulty has been brought up to the point of leaving only a small and known error.

Pellat proposes by his balance to first undertake the determination of the electromotive force of Clark's normal battery, then relative measurements of the electrostatic and electromagnetic units of the C. G. S. system, using, of course, in these an absolute electrometer; finally, to determine the mechanical equivalent of heat in this way: by passing a known current (J) through a circuit of known resistance (R) contained in a calorimeter.—*Lumiere Electrique.*

COMPOSITE STEEL AND IRON.

AT the recent meeting of the Iron and Steel Institute a paper was read on "Patent Composite Steel and Iron," by Mr. George Allan, Corngreaves Works, Birmingham.

In this paper the author reviewed the previous attempts which have been made by various inventors to produce composite material which should combine the good qualities of fibrous wrought iron and of cast steel without having the faults of either. He referred particularly to the failure of steel if subjected to a tearing action proper, such as would apply to the tearing across of a sheet of paper. In these cases there is no contraction whatever of the edges and no reduction of the fractional area, and under such strains the results given by steel are invariably inferior to those given by good fibrous iron.

He referred to a paper read by Mr. Jeremiah Head in 1885, in which it was pointed out that "the homogeneity of steel is the cause of extreme susceptibility to tearing strains. Imagine for a moment a piece of steel plate to be composed of a number of molecular columns, side by side, each column being equivalent in height to the thickness of the plate. Let us now apply a splitting force just capable of overcoming the lateral cohesion of two contiguous columns forming the edge of the plate at a particular place. They are separated, and offer no further resistance; and the force is available to act on the next pair of columns. These separate, and the split proceeds. The view that mysterious cracks in steel are all in the nature of tears seems to be confirmed by the fact that in such cases there is never any appearance of contraction at the fractured edges, notwithstanding the general ductility of the metal. This also may, I think, be explained. Let us suppose that one pair of molecular columns in the line of a crack has come in its turn under the separating strain, and tended to shorten before parting company. It is evident that the pair of columns last torn apart and now free from strain, and the next pair ahead not yet strained, would both act as props and afford support so as to prevent shortening of the then strained pair. In this they would be assisted by all other contiguous columns, whereas if the whole piece of plate were strained equally across while being pulled in two in a testing machine, each molecular column across the line of fracture would be under identical conditions, and none would interfere with the tendency in its neighbors to shorten. Cracks in soft steel plates, unaccompanied by contraction at the fractured edges, must then of necessity be tears; and tears cannot show evidences of contraction. A wrought iron plate is not liable to tears of this kind, because possibly the cinder which permeates it acts as a sort of padding between the molecular columns. Suppose a similar strain to be applied to the edge of an iron plate, and to leave the first pair of columns separated just beyond the range of cohesion. If we were dealing with steel, the next pair of columns would now be sustaining the full brunt of the force. But iron being the material concerned, there would be a padding of cinder intervening, and the next pair (or possibly group) of columns would be some distance off. The gap commenced would have to be widened or wedged out, as it were, before the second row or group was strained beyond cohesion, and for this the range of the original force would, perhaps, be insufficient. To put the case another way, a very finely woven muslin fabric may easily be rent across; but if the threads composing it were rearranged so as to form a coarse net, it would no longer be easily torn, though its combined tensile strength would be unaffected."

The author, after quoting the above passage, referred to the alarm which was caused at the Forth Bridge works some time ago by the failure of a steel plate 1½ in. thick, which, while being bent cold to a radius of 6 ft., broke like a piece of cast iron. There was no fault in the quality of the material, and it was found that the failure was caused by damage which was set up locally by shearing. The difficulty was overcome by planing $\frac{1}{16}$ of an inch off the sheared edge. In another case, which came under the author's personal observation, some soft steel bars which were used for axles failed because a brand which had been stamped in error was removed by filing, all the fractures taking place at the filed portion, whereas those axles which had been made from the rest of the bars were perfectly sound. This experience was rather a startling one, showing how sensitive a piece of homogeneous material like steel is to a tearing action, if only a means of starting the tear exists. A difficulty is sometimes experienced in welding steel, and although it is possible to obtain perfect welds, this requires far more skill than with wrought iron. The composite material of the author is devised to render welding easier, and to remove the danger of tearing, which is always more or less present in the perfectly homogeneous material. It is made for such purposes as axles, chains, boiler plates, rivets, burglar proof safes, etc., and consists of fibrous iron of a high quality, in combination with mild steel. In other words, the author surrounds a series of strands of high quality iron by mild open hearth steel, and rolls the ingots subsequently in bars, plates, or any other desired form. The combination is effected through the casting operation, and is supplemented by the work put upon the material by the subsequent heating and rolling, when the surfaces of steel and iron are perfectly welded together.

Composite ingots are generally made 13 in. square, and parallel from end to end; but the arrangement of the wrought iron bars within the steel varies according to the purposes for which the material is to be used. If for chain making, two pieces of iron plate ⅜ of an inch thick, and measuring slightly less than the inside dimensions of the ingot mould, are punched with a series of forty-eight square holes, to receive an equal number of 1¼ in. square bars of fibrous iron, cut to the length of the ingot, or about 4 ft. 6 in. The two end plates and the bars form a cage, which is heated in a gas flame such as is generally used in steel works for drying the lining of ladles. The cage is then placed in the ingot mould, and steel containing from 0·15 to 0·18 per cent. of carbon is run into the mould in the usual way, the moulds, which are placed round the central runner, being preferably filled from the bottom upward. The ingots thus obtained are heated in an ordinary furnace, and cogged down so as to suit the mill in which the chain material is to be rolled. In treating composite ingots it is found that the oxide on the surface of the wrought iron bars is no obstacle to the perfect union of iron and steel, nor does the iron during any subsequent rolling extend faster than the steel; and the relative proportions of iron and steel are practically maintained, no matter how much the section is drawn or rolled down. The author exhibited a large number of samples, in all of which the two materials could be distinctly seen. The material is made with varying degrees of tensile strength and elasticity. For chains and cables, it is prepared with a strength of from 26 to 32 tons, and an elongation of from 25 to 35 per cent. in a length of 8 in. For boiler plates, the tensile strength chosen is from 25 to 28 tons, with an elongation of from 15 to 26 per cent.

Another application of the composite material is for the manufacture of burglar proof safes. In this case, instead of the bars of iron, the author uses bars of hard steel. Manufacturers of safes have hitherto always considered it necessary to place the rivets so that they cannot be reached from the outside. Drilling out is, however, rendered impossible by using composite rivets made of a soft and tough material, with three or four strands of very hard steel running right through them from end to end. These strands, being only small, take but a nominal area from the tough portion of the rivet, which is, therefore, proof both against drilling out and knocking off. The author also suggested that composite material might be made to combine toughness with a very hard outside surface to resist wear for use in plowshares, mouthpieces of dredger buckets, etc.

MacCORD'S TABLE.

To the Editor of the Scientific American:

In an article on the Limiting Numbers of Teeth, by Mr. George B. Grant, of Boston, published in SCIENTIFIC AMERICAN SUPPLEMENT, No. 592, appears the following:

"MacCord's table, when recess is three quarters of the pitch, makes a pinion of 5·46 *drive nothing less than a rack*, when in fact it will drive anything from a gear of 16·39 teeth to a rack. Similarly, when recess equals two thirds the pitch, *he finds that* 5·30 *teeth will drive nothing less than a rack*, when it can really drive any gear with 10·61 or more teeth." (Italics mine.)

The above is a striking example of what is called in homely metaphor "putting the cart before the horse," though I do not for a moment suppose that the writer mistook the animal for the vehicle, or was himself laboring under the misapprehension into which his words would lead others. The simple truth is this: that under the conditions named, my table shows that nothing less than the numbers quoted *will drive a rack*. It does *not* show that these numbers will drive nothing less than a rack, as asserted by Mr. Grant.

C. W. MACCORD.

Stevens Institute of Technology,
Hoboken, N. J., May 12, 1887.

CORRECTION.

THE WAVE THEORY OF SOUND CONSIDERED.

To the Editor of the Scientific American:

Please note the correction: Line 52, third column, page 9,508, should read, "or less than one foot in five minutes," instead of "or less than one foot in one hour." The third line from the bottom reads: "Just imagine the finger to be moved through the air at a velocity of one foot in one hour. Is it possible that any scientist who considers the problem in connection with the mobility of the air could risk his reputation by saying that the air would be compressed?" This is exactly what I intended to say—as I offered such statement for criticism; the error was as above mentioned, and introduced while copying the article. A tuning fork can be heard to sound audibly for four minutes, when placed close to the ear or through a tube. At the end of three minutes it can be demonstrated that the amplitude of swing of the prong of the tuning fork is not the $\frac{1}{10000}$ of an inch, and that its velocity of motion is less than one foot in one hour and a half.

As some reader may think the weight assigned to the supposed molecule of oxygen, viz., 0·0000000054044 ounce, is too high, I am willing to have this weight divided by a million or a billion, for the absurdity will be sufficiently great, as Tait gives the number of molecules in one cubic inch as 800,000,000,000,000,000,000 (or 8×10^{20}), while in my article I gave only the modest number 3,505,519,800,000,000,000 (or 35^{11}).

HENRY A. MOTT, Ph.D.

New York, June 1, 1887.

IRON AND STEEL ANALYSIS.

By J. JAS. MORGAN.

THE chemicals used in the analysis of iron and steel must be pure, and in all cases the weight of the filter paper ash subtracted from the weight of the precipitates, etc. That this is necessary will be seen from the following example: The silica (SiO_2) + ash of filter paper was found to weigh on 4 grammes of steel, 0·004 gramme, which equals 0·046 per cent. of silicon. The weight of the filter paper ash was 0·002 gramme, therefore the correct weight of the silica was 0·002 gramme, and not 0·004 gramme; which equals 0·023 per cent. of silicon. We shall give directions for the estimation of the following substances: Graphite, silicon, sulphur, manganese, phosphorus, and carbon.

GRAPHITE AND SILICON.—Place 4 grammes of the sample in a state of fine division in a porcelain dish of about 500 c. c. capacity, add 50 c. c. of nitro-hydrochloric acid (made by mixing one part nitric sp. gr. 1·42 with three parts hydrochloric acid), and evaporate to dryness on a hot plate or sand bath. Heat strongly until the mass becomes black, allow to cool, moisten with 50 c. c. of hydrochloric acid, and evaporate down until a crust begins to form on the top of the solution. Add the least possible quantity of hydrochloric acid sufficient to dissolve the crust, dilute with hot distilled water (when water is spoken of, *distilled water* is meant), and filter off the residue, which consists of silica and graphite, through an English filter paper, receiving the filtrate in a beaker. The residue adhering to the sides of the dish is removed by rubbing it with a piece of caoutchouc tubing attached to the end of a glass rod (called a "rubber"), rinsing it into the filter. Wash the filter and its contents; 1st, twice with a two per cent. solution of hydrochloric acid; 2d, with hot water until a drop of the washings, placed on a porcelain slab, gives no coloration with sulphocyanide of potassium. The filter and its contents are then placed in a fireclay dish, and the paper burnt off at a low heat, great care being taken not to employ too great a heat or else some of the graphite will be burnt off as well. Upon cooling, the residue, consisting of graphite and silica, is weighed, replaced in dish, and the graphite burnt off at a bright red heat, allow to cool and again weigh. The second weight (silica) subtracted from the first weight will equal the graphite on the number of grammes used.

To find percentage, multiply by 100 and divide by number of grammes taken.

Example: 4 grammes of the sample taken:

Weight of 1st residue (graphite and silica). 0·300 grm.
" 2d residue (silica)............. 0·200 "

Graphite on 4 grammes.................. 0·100 "

Percentage equals...... Gramme.
As 4 : 100 : : 4) 0·100
0·025
100
2·5 = 2·50 per cent.

To find percentage of silicon, multiply the second weight by 0·466, divide by number of grammes taken, and multiply by 100. As steel contains only very minute quantities, if any, of graphite, the residue obtained upon treating the sample as described is burnt at a bright red heat and weighed as silica, SiO_2, which contains 46·67 per cent. of silicon (Si).

SULPHUR.—Is usually estimated as barium sulphate ($BaSO_4$). Evaporate the filtrate from the silicon down to about 50 c. c., dilute with 700 c. c. of water, and add 5 c. c. of barium chloride solution—made by dissolving 1 part of the salt in 10 parts of water—mix; cover the mouth of the beaker with a watch glass, and allow the solution to stand in a warm place for twenty-four hours. At the end of this time filter the solution (the greater portion of which may be siphoned off, care being taken not to disturb the precipitate) through a Swedish filter paper, removing the precipitate adhering to the bottom and sides of the beaker by means of the rubber. Wash, 1st, three times with a 3 per cent. solution of hydrochloric acid; 2d, well with hot water; burn in a platinum crucible, and weigh the barium sulphate, which contains 13·73 per cent. of sulphur. A quick and fairly accurate method for the estimation of sulphur is to treat the steel or iron with dilute sulphuric acid, passing the evolved gases through a solution of copper sulphate, which precipitates the sulphur as copper sulphide, Cu_2S, which is collected, burnt into CuO, and weighed.

The process is as follows: The flask, A, which has a tube, C, bent at right angles welded to the neck, is fitted with a caoutchouc cork, through which passes the safety acid funnel, B, reaching nearly to the bottom of flask, and in it placed 10 grammes of the steel or iron. Fill the cylinder, D (of 200 c. c. capacity), with 160 c. c. of sulphate of copper solution, made by dissolving 50 grammes of the crystals in one liter of water, and place the flask over a Bunsen burner or spirit lamp, so that tube, C, reaches nearly to the bottom (inside) of the cylinder, D, containing the copper sulphate solution. Through funnel, B, pour upon the sample sufficient dilute sulphuric acid to cover the bottom of the flask to a depth of two inches. The evolved gases, consisting of sulphureted hydrogen, etc., pass through into the copper sulphate solution, where the sulphur of the sulphureted hydrogen combines with the copper, forming a black precipitate of copper sulphide, Cu_2S. Toward the end the action may be hastened by applying a gentle heat. When gas ceases to be evolved, pour hot water through B until mark, E, is reached; remove tube, C (by raising the flask), washing any of the precipitate adhering to it back into D with *cold* water. Filter contents of D, well wash with *cold* water, ignite at a red heat, and weigh the resulting copper oxide, CuO. To convert the CuO into sulphur, multiply by 0·7985.

MANGANESE.—Dissolve 2 grammes of the sample in 50 c. c. of nitro-hydrochloric acid, and upon complete solution transfer to a flask of 2 liters capacity, add 1½ liters of hot water. To this solution, ammonia is cautiously added, shaking well after each addition, until a slight permanent precipitate commences to form, and then 200 c. c. of hot ammonium acetate, the iron will be precipitated as a basic acetate of iron, boil, and allow the precipitate to settle. Filter through a large filter, and well wash the filter and its contents. In all probability, the filtrate will not run through clear, showing that the precipitation of the iron is incomplete. This is rather to be desired than otherwise, because if all the iron has been precipitated, in all likelihood it would have carried down some of the manganese with it. Should this be the case, the filtrate is boiled and refiltered. It is then evaporated down to 500 c. c.; filtering off any precipitate which may have come down during the operation, and allowed to cool.

To the solution add a slight excess of ammonia, then a small quantity of bromine, and finally an excess of ammonia, agitating after the addition of each reagent. Boil and filter off the precipitated hydrated oxide of manganese, wash well with hot water, convert into trimanganic tetraoxide, Mn_3O_4, by ignition at a white heat, and weigh. The Mn_3O_4 contains 72·00 per cent.

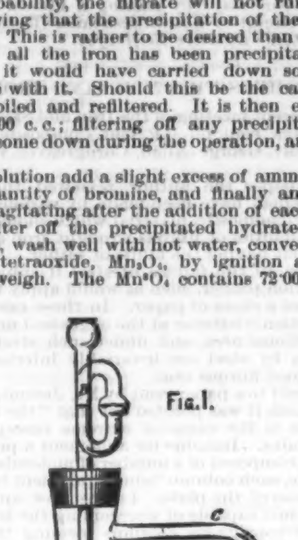


FIG. I.

of manganese. It is advisable to test the manganese precipitate for iron, which is done by dissolving it in hydrochloric acid, withdrawing a drop on the end of a glass rod and bringing it in contact with a drop of sulphocyanide of potassium on a porcelain slab, when, if iron is present, a red coloration will be formed. If iron is detected, the remainder of the solution is diluted with about 60 c. c. of water, ammonia added until neutral, and the iron precipitated with ammonium acetate, boil, filter, burn, and weigh the ferric oxide, the weight of which is subtracted from the weight of Mn_3O_4 found.

The method given below, which is a combination of the "potassium chlorate" and "bromine methods," and which the author has found to give accurate results, has several advantages over the bromine method—1st, a larger quantity of the sample may be taken; 2d, the larger bulk of iron is got rid of; 3d, the time occupied in performing the analyses is less.

The method is as follows: Weigh 4 grammes of the sample, place in a conical flask, and dissolve in 50 c. c. of nitric acid, sp. gr. 1·20. When dissolved, add 22 c. c. nitric acid (sp. gr. 1·42) and 6 grammes potassium chlorate, and boil for ten minutes. At the end of this time add 10 c. c. nitric acid (sp. gr. 1·42) and 8 grammes of potassium chlorate, and boil for fifteen minutes. Allow to cool, and dilute with *cold* water. Pass the supernatant solution through a Swedish filter paper, allowing the precipitate of manganese dioxide (MnO_2) and a little iron oxide to remain in the precipitating vessel. Dissolve in hydrochloric acid any of the precipitate which may be on the filter, receiving it in the flask which contains the precipitate; add hydrochloric acid to dissolve the MnO_2 precipitate; dilute; throw down the iron with ammonia and ammonium acetate; filter; cool the filtrate; and precipitate the manganese with ammonia and bromine.

Phosphorus may be estimated either as phospho-molybdate or pyro-magnesium phosphate, but we shall only give a description of the former process. Take 4 grammes of the sample (in the case of high percentage, two or even one gramme is quite sufficient), dissolve in 50 c. c. nitro-hydrochloric acid, and evaporate down to dryness. Heat the mass until it becomes black, as in the estimation of silicon. Unless the mass is heated, all the phosphorus will not be oxidized into phosphoric acid, some of it remaining as phosphorous acid, which is not precipitated by ammonium molybdate.

When cool add 50 c. c. hydrochloric acid, evaporate down to a small bulk, dilute, and filter off the silica, etc. To the filtrate add 40 c. c. nitric acid (sp. gr. 1·42), and evaporate down until it measures 50 c. c. To this solution add 10 c. c. nitric acid (1·42) and 50 c. c. of the ammonium molybdate solution; shake well, and allow to stand in a warm place for ten minutes. If all has gone well, the phosphorus will be precipitated as a yellow precipitate. Ascertain, as far as can be judged by smell, whether the solution is acid or ammoniacal; if strongly acid, add ammonia until it is only slightly so (it is advisable to have the solution slightly acid to prevent ammonium molybdate being precipitated); if ammoniacal, add nitric acid until slightly acid. When this point is reached, allow to stand in a warm place until the supernatant liquid is perfectly clear, filter through a *weighed* Swedish filter, rinsing the precipitate on the filter with a dilute solution of nitric acid (one part acid to ten water). Wash four times with the nitric acid; dry the filter paper and its contents in the water oven and weigh. The weight, minus the weight of the filter paper, equals the phospho-molybdate, which contains 1·63 per cent. of phosphorus.

PREPARATION OF AMMONIUM MOLYBDATE SOLUTION.—Dissolve 50 grammes of ammonium molybdate in one liter of water, and add 150 c. c. ammonia (sp. gr. 0·880). Allow the solution to stand for a few days and decant from any precipitate which may have formed.

CARBON.—(Colorimetric method.)—When steel or iron containing combined carbon is dissolved in nitric acid, the solution becomes of a brown color, varying in depth in proportion to the amount of carbon present. Upon this Eggertz's color test is founded. With steels that have been hardened or contain more than 0·80 per cent. of combined carbon, the method does not give reliable results. In using the method it is necessary to have a standard steel of the same make, in which the carbon has been carefully estimated by the combustion process, and containing, as near as possible, the same percentage as the sample to be tested.

METHOD.—In a dry test tube, ⅝ in. diameter and 6 in. long, place 0·2 gramme of the sample to be tested, and in a similar tube the same quantity of the standard steel; to each 5 c. c. of nitric acid (sp. gr. 1·20), free from chlorine. When all action is at an end, the tubes are placed in a beaker containing boiling water, and allowed to remain for fifteen minutes; the tubes are then withdrawn and placed in a beaker of water (cold) to cool. Into a graduated tube of 200 c. c. capacity (divided in $\frac{1}{10}$ c. c.) pour the standard solution, rinsing the last portion in with the smallest quantity of water (cold) possible; dilute with water, and mix, by placing thumb on top of tube, and turning upside down.

A good plan is to dilute the standard until the number of c. c. it occupies is divisible into the percentage of carbon it contains. Thus, if the steel contains 0·14 per cent. carbon, dilute to 7 c. c.; if 0·36 per cent., to 9 c. c.; and so on. The solution of the steel to be tested is then transferred to graduated tube of the same caliber as that used for the standard, and after rinsing in the last portions mixed *without dilution*. Compare the color with that of the standard, and if darker, cautiously add cold distilled water until the tints are similar. (To compare the colors, hold the tubes side by side before a window with a piece of plain white paper behind them.) When the colors correspond, read off the numbers of c. c., which, multiplied by the quotient obtained by dividing the number of c. c. to which the standard was diluted into the per cent. of carbons it contains, will give the per cent. of carbon in the steel.

ESTIMATION BY COMBUSTION.—When steel or iron is placed in a solution of copper sulphate, the iron displaces the copper and enters into solution; while the copper, together with the phosphorus, com. carbon, graphite, silicon, and sulphur, is deposited. Upon treating the carbonaceous residue with sulphuric and chromic acids, carbon dioxide is formed, which may be absorbed by passing through a solution of caustic potash. This is the principle of Ullgren's method.

In a beaker containing 150 c. c. of copper sulphate solution—made by dissolving 200 grammes of sulphate of copper crystals in one liter of water—place 4 grammes of the sample, and heat gently with constant stirring. Should the solution become colorless, add more of the sulphate solution. When the iron has completely dissolved, allow the residue to settle, and pour off as much as possible of the supernatant solution. Rinse the residue, together with the remainder of the copper sulphate solution, into the flask, A, using the smallest quantity of water possible, and connect with the rest of the apparatus. Through the acid funnel add 100 c. c. strong sulphuric and 16 grammes chromic acids (dissolve 16 grammes chromic acid crystals in 10 c. c. water) and apply a gentle heat, regulating it so that a regular evolution of gas is maintained.

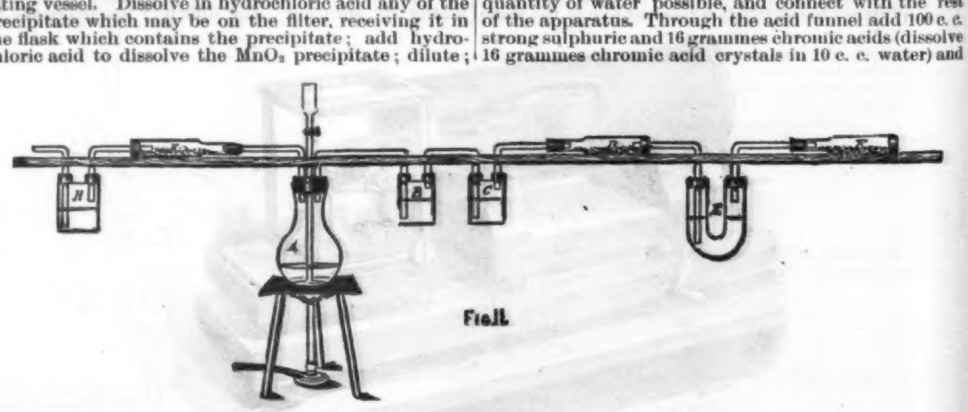


FIG. II.

The gas passes through B, containing a solution of sulphate of silver in sulphuric acid, to absorb any chlorine, into C and D (which contain sulphuric acid and calcium chloride to dry the gas), and then into the U tube, E, containing caustic potash, which absorbs the carbon dioxide. When white fumes begin to appear in A, the heat is withdrawn, and a current of air drawn through the apparatus, and when cool the tube, E, is weighed. The difference in the weight before and after the experiment equals the carbon dioxide absorbed, which contains 27·27 per cent. of carbon. The tube, F, which is weighed before and after the experiment, contains calcium chloride, so absorbs any water which may be driven off from the caustic potash solution by the heated gas. H and K are filled with caustic potash and calcium chloride to rid the atmospheric air of its carbon dioxide and moisture.—*Industrial Review.*

ANTOINE LAURENT LAVOISIER.

THE science of chemistry is aptly said to be based upon the foundations laid by three men, Lavoisier, Priestley, and Scheele. Just as physics had been hampered by the material theory of heat or "caloric," so chemistry had been retarded by the phlogiston theory. Facts had accumulated. The work of Scheele's life had brought the knowledge of chemical compounds wonderfully forward. Yet the weight-annihilating phlogiston, similar to the "negative gravity" of Stockton, the novelist and story writer, had prevented the formulation of a tangible theory. Lavoisier was one of the first to apply rigorous quantitative methods to chemistry. He made the balance the arbiter of all questions. He found that a substance invariably gained weight in burning, and determined the amount of this increase. According to the chemistry of those days, of Stahl and the scientists of his age, burning was dephlogisticating, or removing phlogiston from the substance burned. Thus, if metallic tin was calcined, producing invariably a quantity of oxide exceeding in weight the original tin, it was assumed that phlogiston had been removed from it, and this removal was assumed to increase the weight.

In 1774, Priestley discovered that by heating red oxide of mercury a gas was produced. He confined the oxide of mercury in an inverted bell jar, where it floated upon metallic mercury with which the rest of the vessel was filled. The oxide was pressed upward by the metal against the top. By a burning-glass he concentrated the rays of the sun upon the oxide thus confined, whereupon the level of the metal rapidly sank as the gas was evolved. The gas was oxygen. About the same time Scheele also discovered it, but did not make known his results.

This discovery was the death blow to the phlogiston

LAVOISIER.

theory of chemistry. The anomalous phlogiston, the weight-destroying substance, was done away with forever. A year after his discovery Priestley went to Paris, and communicated his results to Lavoisier. The latter was in the full tide of his work of reorganizing chemistry. The discovery of oxygen gave him the stepping stone on which to build his theory. Scheele by his long life of discoveries had furnished additional facts for the new science. Lavoisier by his severely logical mind and wonderfully perfect methods of working founded the science as an entirety.

Lavoisier calcined a weighed amount of tin, and had weighed the oxide produced. He burned the diamond, and found that carbonic acid gas was produced. He acted upon air with phosphorus, and found that one fifth of its volume disappeared. The discovery of oxygen, communicated to him by the English theologian Priestley, gave the clew to the explanation of all these facts. Here was a weight-possessing element that produced oxidation, so that the latter phenomenon became one of combination instead of dissociation. At once the new chemistry was built upon this foundation. So eagerly did Lavoisier promulgate the new theories that he excited jealousy among his brother scientists, a jealousy which, in the extraordinary days he lived in, may have contributed to his death at the hands of the French revolutionists. So great was his part in laying out the new scheme of chemistry that the French, with much reason, claim it as a French science. Thus he established the constitution of oxides, of oxygen acids, and of oxygen salts. For many years the haloid salts were considered, under the impetus of the new discovery, to also contain oxygen. He determined the constitution of metallic sulphides.

The recent discovery of a hitherto unpublished letter by Lavoisier is the motive of thus presenting his portrait. The letter will be found below. The leading features of his life may be properly summarized here.

He was born in Paris, in August, 1743. His father was wealthy, so that he enjoyed every advantage of education. A student at the Mazarin College, he gave much attention to the natural sciences. The astronomer La Caille, the chemist Rouelle, and botanist De Jussieu, names now almost forgotten, are mentioned among his preceptors. Among his first researches may be mentioned his work on the illumination of the streets of large cities. In those days, before the invention of gas, it was a most serious problem how to properly light the cities. Crime took every advantage of the darkness that prevailed. To qualify himself for this investigation he lived in a darkened room for six weeks, in order to increase the sensitiveness of his retina. For his memoir on the subject, presented in 1766, he received a prize from the Paris Academy of Sciences. In 1768 he was admitted to the Academy in virtue of this and other essays, some on geological subjects. In 1776 Turgot put him at the head of the *regie des salpetres*, to whose charge was confided the powder manufacture of the kingdom of France. Into this art he at once introduced important improvements, that made the French gunpowder one third stronger than formerly. From 1778 to 1785 he gave much attention to scientific agriculture. In 1787 he was a member of the Orleans provincial assembly. He had a part in preparing the new decimal system of weights and measures in 1790. In 1791 he became commissary to the treasury, and established a new and unheard of system of punctuality. At the request of the national assembly he set forth a scheme of national taxation, and his memoir on the subject shows him to have been a skillful political economist. In 1769 he had obtained the position of farmer-general of the revenues, and had held it for twenty-one years. He had obtained it in order to have sufficient revenue to devote himself exclusively to science. His position was made the basis of an accusation against him.

The farmers of the revenue of a preceding generation had accumulated immense fortunes from their positions, and had led lives that by their extravagance and luxury were a standing reproach to the system. This had been reformed under Louis XVI., and the farmers of the revenue of the time were free from cause for reproach. But they had to suffer for the sins of their predecessors, though innocent themselves.

In 1793 the subject was brought before the national assembly. A series of accusations were made, and most of the farmers were placed under arrest. Lavoisier had eluded the police, but fearing that his absence would affect the others unfavorably, gave himself up. The story of the proceedings is told at great length in the *Revue des Deux Mondes* of Feb. 15, 1887. To this we must refer our readers for the details of the proceedings. A series of frivolous and unproved charges was enough to bring them all to the guillotine. Lavoisier anticipated the confiscation of his property, and had resolved to practice pharmacy for his living. He was desirous to collect his writings for publication. But the temper of the times did not permit this. On the 6th of May, 1794, he, with twenty-seven other farmer-generals, was condemned to the guillotine, and on the 8th of May the sentence was executed. He was engaged in preparing a collection of his works, but his execution came before he had completed it.

His great work was in chemistry. Eagerly availing himself of the discovery of Priestley, and of his own work on carbonic acid gas, embodied in a memoir of 1792, he applied his unequaled intellect to the plan and theory of the science, and became the founder of modern chemistry.

The letter whose translation we give below shows what marvelous quantitative work he executed. In this he was half a century in advance of his time. As has just been stated, he remorselessly applied the balance to testing the theory of chemistry, and the results described in this letter show how well he did his work.

The engaging tone of modesty and candor are very noticeable, and display a most amiable character. The portrait is from a painting by the great David. It is curious that David, who voted in the national assembly for the death of Louis XVI., should have been the painter of Lavoisier's portrait, who himself was a victim of the revolution. It makes the painter in some sort responsible for the death of the greatest of France's chemists, him whose features he himself had with such inspiration transferred to canvas. The death of Lavoisier reminds us of the death of Archimedes. Both are blots upon the pages of history.

He was married in 1771 to Mlle. Paulze, but left no posterity.

The last of Lavoisier's memoirs on physiology was one embodying the results of experiments undertaken by him in consort with Seguin, and which, after being read at the Academy on April 14, 1790, was not published until 1797, by the efforts of Seguin (see Oeuvres Completes, vol. ii., p. 704). But later than this period Lavoisier continued his researches, as the following letter to Black testifies, which is in Lavoisier's minute autograph:

M. Black, Professor in the University of Edinburgh.
Sent November 13, 1790.

M. Terray, monsieur, forwarded to me, on reaching Paris, the letter you did me the honor to write on the 24th of October. He could have made me no more agreeable present. I believed that you would not object to my communicating it to the Academy of Sciences. The elegance of the style was no less admired than the depth of philosophy and clearness that pervades your letter, and I was requested by it (the Academy) that it should be deposited in its archives, but I only consented to this on condition that a copy certified to by the secretary should be sent to me. I have another favor to ask of you, but concerning which I await your instructions. It is to permit me to publish a translation of it in the *Annales de Chimie*.*

M. Gillan, during his sojourn in Paris, witnessed some experiments which I made upon respiration, and he was so kind as to assist in them. We convinced ourselves of the following facts:

1. The quantity of vital air, or oxygen gas, which a man at rest and fasting consumes, or, rather, converts into fixed air or carbonic acid, during one hour, is about 1,200 French cubic inches, when he is placed in a temperature of 26 degrees.

2. This quantity rises to 1,400 inches under the same circumstances if the person is placed in a temperature of only 12 degrees.

3. The quantity of oxygen gas consumed or converted into carbonic acid increases during the time of digestion, and rises to 1,800 or 1,900 inches.

4. By movement and exercise it may be raised to 4,000 inches per hour, and even more.

5. The animal heat is constantly the same in all the cases.

6. Animals can live in vital air or oxygen which is not renewed as long as is judged proper, provided care is taken to absorb by caustic alkali liquor the carbonic acid gas as fast as it forms, so that this gas does not need azote or mophette gas, as has been believed, to be salubrious or fit for respiration.

7. Animals do not seem to suffer in a mixture of fifteen parts of azote gas and one part of oxygen gas, provided one takes the precaution of absorbing the carbonic acid gas by means of caustic alkali as fast as it forms.

8. The consumption of oxygen gas and its conversion into carbonic acid is the same in pure oxygen gas and in oxygen gas mixed with azote gas, so that the respiration is not at all accelerated on account of the purity of the air.

9. Animals live quite a long time in a mixture of two parts of inflammable gas and one of oxygen gas.

10. Azote gas performs absolutely no service in the act of respiration, and it leaves the lungs in the same quantity and quality with which it entered.

11. When by exercise and motion the consumption of oxygen gas in the lungs is increased, of which it is easy to assure one's self by the beating of the pulse, and in general when a person breathes without disturbing himself, the quantity of oxygen gas consumed is proportional to the increase of the number of pulsations multiplied by the number of inspirations.

It is proper, sir, that you should be one of the first to be informed of the progress which is made in a career which you have opened, and in which we all regard ourselves as your disciples. We pursue the same experiments. I will have the honor to inform you of our later discoveries.

I have the honor to be, with a respectful attachment, etc.

TAKING A BULLET FROM THE BRAIN.

THE instances when men have carried bullets in their brains and lived are nearly as rare as the fabulous hen's teeth. Colonel Henry Pickens, who was discharged from Bellevue Hospital recently, afforded a notable case. He was an officer in the Confederate army. His home is at Lexington, Ky. He was wounded at the battle of Gettysburg in 1863. Since that time he has carried a bullet constantly in his brain. It gave him pain from time to time, varying in intensity. Of late years it had been more painful. Physicians who were acquainted with his case told him that it would kill him, yet he went home to Lexington, sound in body and mind, with the bullet extracted. How narrowly he escaped death may be gathered from the particulars of his case.

Nearly eight weeks ago the bystanders at the corner of Broadway and Fourth street saw a well dressed man walking slowly up the street, leaning heavily on a cane. Just as he got to the corner he staggered against a window. He seemed to recover his balance by the power of will, but after taking a few more steps he stopped suddenly, raised his hands to his head, and fell prostrate. Blood oozed from a wound in the forehead where he had struck. An ambulance was summoned. It was some time before it came clattering along the street, sounding the sharp gong. The ambulance surgeon saw that the prostrate man was breathing heavily. There was no odor of alcohol about him. He was picked up and hurriedly driven to the hospital. There was nothing in his clothes to lead to his identification. The word "unknown," that is so often written on the records of the hospital, was entered in the book at the end of a brief description of his appearance.

From what could be learned about the case, it was

* Black's letter appeared in the *Annales de Chimie* of 1791 (vol. viii., p. 225).

thought that the man was suffering from a stroke of paralysis. The left side seemed to be most affected, though the entire body showed the distinguishing marks of the disease. The patient was kept quiet for several hours, awaiting a possible abatement of the shock. Then, as there were no signs of improvement, a strong electric bath was given. It was kept up for about an hour, and was followed by vigorous rubbing, sharp skin irritations, cold applications to the head and warm ones to the feet. There was an improvement in the patient's condition, but it was only temporary. There was no lucid interval. Whatever there was of virtue in medicine was tried. When nothing more could be done to revive the patient, he was put into a cot and left in quietness to await the coming of the dread messenger, who it was thought was close at hand.

While putting a bandage on the patient's head, Dr. Parker, who makes a specialty of the brain and its injuries, noticed an old scar on the left side of the head. Upon putting a light pressure on the skull at this point it was found to be indented and to be formed of an elastic cartilagenous substance. What could have been the cause of this condition? In Dr. Parker's opinion there had been an injury to the bone, probably a fracture, and relief had been given by trephining. This threw new light on the patient's case. It awakened a strong probability that the brain had been injured by a blow, and that the unconscious condition was the result of the gradual development of an obstruction to the normal action of the brain. What the obstruction was could only be a matter of conjecture. There was no history of the injury that could be obtained either from the patient himself or his friends, as they were unknown. It was evident from the peculiar formation of the indentation that there had been a serious laceration of the brain substance.

Dr. Ferrier has demonstrated by experiment upon living animals that the brain consists of motor areas, and that by applying a galvanic current to a particular portion of the brain it would always be followed by certain movements in the same muscles. Dr. Parker was with Dr. Ferrier for a long time in France, and became deeply interested in the subject of the motor areas in the brain as indicating a method of relief in injuries to the brain. He has been a deep student, and both on animals and the human being he has conducted experiments to localize to areas in the brain the control of particular muscles. He has found by experiment that the muscles of the left hand and arm were seemingly controlled by a section of the brain in the right side of the head near the center. In the unconscious man it was found by close watching that he could move his left leg much better than he could his left arm, though not as well as he could the hand and arm on the right side of the body. The left arm was cold and was entirely without moving power. From these conditions Dr. Parker concluded that there was some brain inteference in the right side of the head, near the top. Well, of what value was this to the surgeon? It pointed out a probable means of relief. It is true that there was nothing certainly demonstrated, and to follow the indications was largely experimental and hazardous: but as there was none of the patient's friends to consult with, and the patient himself could not speak, the surgeon did what he thought was best for the patient and the interests of science.

The patient was removed to the operating room, and, in the presence of a large number of physicians, the surgeon cut off the patient's hair on the right side, and made a triangular incision in the scalp about three inches long. The flesh was dissected up within the lines of the incision, and a long flap was made. Without a moment's hesitation the surgeon forced a trephine of the largest size through the skull, which was unusually thick and hard. A button of bone was removed about an inch and a half in diameter, and the brain substance came up through the opening in the skull, showing that there was pressure within. There was nothing in the appearance of the brain to indicate that there was anything wrong near the surface. Upon pressing the brain back through the opening, which could be easily done, as the membrane was not ruptured, the surgeon detected with his fingers a hard substance on the under side of the opening. A piece of bone was removed at this point with fine forceps, and a cystic tumor was found embedded in the brain. How deep it extended could not be told, but the surgeon at a venture sank his knife into the brain substance and began cutting the tumor out. It was delicate work and skillfully done. After about an inch and a half of the brain had been divided, the end of the tumor was found, and the entire mass was removed without much difficulty. A large hole was left in the brain, and there was considerable hemorrhage, which fortunately did not last long. While the flap was being returned to position on the skull, one of the assistants cut the tumor in half to discover its nature, and was surprised to find firmly embedded on one side a large bullet. It was much flattened, and looked like one of the largest revolver bullets.

The patient lingered between life and death for many days, and then there was a marked improvement in the condition of his body. The temperature became normal and the power of motion slowly returned. The improvement was steady, and at the end of four weeks the patient had become conscious, and soon afterward was able to talk without trouble. It was then that his name and the circumstances told in regard to him first became known.—*N. Y. Sun, May 23, 1887.*

CURIOUS OPTICAL ILLUSION.

TAKE a whitewood rectangular box, and into one of the sides drive a nail. To the head of the latter affix a ten cent piece by means of wax or resin. Alongside of the nail, and directly to the surface of the wood, affix a silver five cent piece. If, now, you look at these two coins through a minute round aperture made in a cardboard screen, it will be impossible to distinguish one from the other, for both will appear to be of the same size.

It is unnecessary to say that the two coins should be fixed "tail" down, so that only the "head," which gives no indication of the value, shall be seen. The distance at which the coins should be placed from the observer's eye varies according to the quality of the sight. In order to succeed with the experiment, it is well to place the eye against the hole in the screen (which should be rendered immovable), and to move the box backward and forward. A point will be finally obtained (varying in distance from six to ten inches) at which the eye sees the two coins of the same size. Upon then gradually diminishing the distance, the five cent piece will even seem to be larger than the ten cent one.

This experiment is explained by the fact that the eye; when situated under the conditions indicated, no longer estimates the distance that separates two objects. It

AN OPTICAL ILLUSION.

is through an analogous phenomenon that the moon, when observed in the finder of an astronomical telescope, appears smaller than it does to the naked eye, while it is really magnified by the instrument.—*La Nature.*

RECENTLY the Emperor William laid the foundation stone of the great ship canal which is to connect the North Sea with the Baltic, and to be finished in seven years. Running from Kiel to the estuary of the Elbe below Hamburg, it will be of sufficient width and depth to give passage to the largest ironclads in the imperial navy, and give easy access for her fleets to the North Sea, not only increasing her ability to defend her coast, but enabling her to take the offensive afloat.

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